Banking service quality management using fuzzy FMEA (a case study: Central Melli Bank of Rafsanjan)

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Abstract: The purpose of all service institutions, including banks, is to provide appropriate services for the customers’ satisfaction. Therefore, due to the importance of quality in service industries and its significant effects on customer satisfaction, the question arises: how the quality of service can be evaluated? This case study also sought to assess the quality of banking services using failure mode and effect analysis (FMEA) techniques in fuzzy environment in one of the branches of Melli Bank of Rafsanjan. In FMEA technique, the risk priority number (RPN) index was used for rating the failure items, which is the multiplication of three risk factors: occurrence of failure, severity of failure and detectability of failure. In FMEA technique, the weights of risk factors weight are not taken into account, such that, the same weight value is assumed for each of those factors. To overcome this weakness, much research has been performed, recently. This paper uses Wang and colleagues’ model in a fuzzy environment. The results illustrate that one of the most significant failure items is lack of a proper location to park the customers’ car.

Keywords: quality of banking services; fuzzy logic; risk priority number; RPN; failure mode and effect analysis; FMEA.

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1 Introduction

In the past, demands and needs of customers paid little attention for several reasons, including increased demand and limited competition in various areas and people had to get their required goods and services in any quality. With the increase in the share of service sector in developed countries, followed by developing countries, quality customer service is located at the centre of marketing concepts for the service organisations in today’s world. Over the past few decades, the issue of service quality has attracted the administrators, experts, and researchers’ attention to it because of dramatic impact on business performance, lower costs, customer satisfaction, customer loyalty, and profitability. Service quality is introduced as an important factor in the success of service organisations. This concept is very close to the concept of customer satisfaction and we can say that these two concepts are hardly intertwined. Since customer satisfaction is one of the most important indicators of organisation marketing, service quality has been highly attended by researchers (Anvari Rostami et al., 2005).

The researches showed that high quality and affordable services promoted customer motivation for the reuse of services and more importantly caused his advertisement for the organisation and others’ attraction to the organisation (Anderson and Fornell, 2010). Bank is not exception of the said issues as a service organisation. Banks have always been one of the main demands of bank clients as the customers of the banks in the quality of provided services (Sobhanifard and Kharazian, 2011). Banks are spreading across the borders by offering a variety of benefits and competitive services, and restructuring services to use the rapid technology in order to fulfil the changing needs of customers. Due to such actions, the nature of banking services and relationship with customers has changed. The very competitive and rapidly changing environment that banks are forced to continue their activities leads them to revise their attitude towards customer satisfaction and optimise service quality. Many companies are realising that consistently delivering of top quality services can bring a strong competitive advantage to the competitors (Horotiz, 2001).

This study used the failure mode and effect analysis (FMEA) to improve the weaknesses of the organisation and increase customer satisfaction in order to identify potential risks, strengths and weaknesses in the organisation.
2 Theoretical framework

2.1 The concepts of service quality

Service quality can be defined as quoted by Zeithaml as the customer evaluation of the advantage or overall excellence of a service, or overall perception of the consumer of inferior rank or excellence of the organisation and its services due to the intangible, heterogeneous and inseparable nature of services. Zeithaml et al. have also defined service quality as “the difference between customer expectations or desires and their perceptions” (Frost and Kumar, 2000). Two dominant schools of thought in the field of service quality are the Northern European School and two-dimensional model of Gronerz and the North America School. Five-dimensional model of SERVQUAL is based on Parasuraman, Zethamel, and Berry. Conceptual models of service quality enable management to identify quality issues and thus help planning to implement the programs of quality improvement. Therefore, the effectiveness, profitability, and overall performance are improved (Seth et al., 2005).

2.2 Quality of bank service

Willingness to services quality plays an important role in service industries, such as insurance and banking services, and so forth because quality of service is critical for the survival and profitability of organisation. In the context of banking services, quality of service is defined as a customer’s belief or attitude towards the level of service excellence that is provided in a bank environment (Al-Hawari et al., 2009).

2.3 Failure mode and effect analysis

FMEA is a systematic tool and a completely subjective preventive approach based on teamwork that is applied to define, identify, assess, prevent, eliminate or control the modes, causes, and effects of potential errors in a system, process, plan or service (before the product reaches customer with its final service) and it is essential to predict errors and how to avoid them (Krouwer, 2004).

Failure mode and effects analysis dates back to more than 50 years. In the late 1950s, the importance of safety issues and prevention of predictable accidents in the air-space industry was the main reason for the emergence of FMEA in the USA (McDermott et al., 2000). Later, this method was raised as a key tool for increasing safety in the chemical industry processes and from then on, the purpose of FMEA was defined as the prevention of accidents and events. In February 1992, SAE-J-1739 standard was introduced as the FMEA reference standard in the automotive industries and followed it in recent years, the development of quality assurance systems in the automotive industry in particular, the status of QS-9000 standard in the US led to prevail the use of FMEA (Almannai et al., 2000).

Ranking of potential failure modes in FMEA approach is done according to the calculation of priority grade index [risk priority number (RPN)] that is achieved by the product of three factors of probability of failure occurrence, severity of failure impact, detection capability (Segismundo et al., 2008). The occurrence is introduced as the probability of occurrence of a cause/mechanism. The severity is the evaluation of potential effects of failure on the other component or subsystem and or customer.
Capability to discover shows the evaluation of ability of potential mechanisms/cause detection before the creation of errors (Ireson et al., 1995).

These three factors are estimated by the experts in the banking services based on a scale of 1 to 10. Since RPN is a measure of the risk of failure, it can be used to rank failure and prioritise attempts. The severity and incidence are dealt with directly and the capability of detection is explored reversely when RPN is calculated. Therefore, if the value of this index is greater, the intended failure will be more critical and corrective actions associated with it will have higher priority. Thus, the technique can take measures to reduce the chances of the occurrence of errors and failure and help the users to specify overall characteristics in the design and process that require special control. See the fully technical description in McDermott et al. (1996).

The use of this technique has been approved by the researchers as one of the most important techniques of quality. However, despite the widespread and appropriate use of the services that it may have in the services, it has not been paid a good attention. In this paper, it was tried to identify potential and actual errors and failures through the technique in the banking system and rank them by failure analysis methodology and its effects.

FMEA modes are based on the study of possible failure modes in the parts and production sectors. Therefore, the first step in implementing failure modes analysis technique and its effects will be to determine a list of available sectors and parts for the detection of possible FMEA (Pinna et al., 2008). It does not include the parts and devices in the input and production processing services. Therefore, in order to implement the technology, the requirements and particular characteristics of the service production process should be considered with a soft view. Laibkoal’s view can be best used to segment the production process and service provision. The requirements of customer satisfaction with the service production will be examined with a result-oriented approach (customer-centred) in this view.

2.4 FMEA in fuzzy environment

However in FMEA approach, for rating potential failure states the RPN index was calculated which is the multiplication of three risk factors: probability of occurrence of failure, severity of failure and detection capability of failure (Segismundo et al., 2008). Severity is the importance of an event, often with respect to some hazard, Probability is the likelihood of the occurrence of an event and fault detection is a method to signal that an error event has occurred. If detection and recovery are successful, the effect of the error event will be prevented (Krouwer, 2004). A numeric ranking of one to ten of each failure mode’s including severity, probability and detection capability is used. The bigger number shows the worse effect. The main core of the technique is human’s understanding and mind, thus we are facing a vague and undetermined issue and it is not possible to dedicate a fixed quantitative value for the triplet parameters. It seems that Fuzzy Technique is able to categorise the factors mathematically.

2.5 Review of the literature

The review and evaluation of the quality of products is ongoing for many years. However, the evaluation of services quality has started mainly since 70 AD and is in the course of its development (Akbaba, 2006). Conceptual model of service quality was
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initially introduced by Parasuraman et al. offering the concept called service quality gap in the gap analysis model framework in 1985. They introduced service quality as the gap between customer expectations of services and his perceptions of the received service (Zeithaml et al., 1985).

Hence, Parasuraman et al. proposed an instrument for measuring service quality following their research based on previous research and gap analysis conceptual model. This instrument was introduced as SERVQUAL model in the service quality literature. SERVQUAL model has the standardised components that is used to measure customer expectations and perceptions of the quality of services so that it is one of the most widely used models for evaluating customers’ expectations and perceptions of quality of service (Parasuraman et al., 1988).

The following are examples of studies that have been used to assess the quality of banking services:

<table>
<thead>
<tr>
<th>Row</th>
<th>Authors</th>
<th>Title of the study</th>
<th>Results of the study</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Anthony (2001)</td>
<td>Staff’s assessment of banks and credit institutions service quality</td>
<td>This research shows that the quality of service in the American credit institutions was more satisfactory than the banks of the country</td>
</tr>
<tr>
<td>2</td>
<td>Broderick and Vachirapompuk (2002)</td>
<td>Service quality in internet banking: the importance of customer’s role</td>
<td>This study has provided the model of internet banking service quality with a focus of the role of customer</td>
</tr>
<tr>
<td>3</td>
<td>Yavas (2007)</td>
<td>Evaluation of service quality: a comparative study of Turkish and German bank customers</td>
<td>The results showed that the level of cultural adaptation among bank customers in Turkey and Germany was strong</td>
</tr>
<tr>
<td>4</td>
<td>Petridou et al. (2007)</td>
<td>Quality of banking services: empirical evidence of banks’ customers in Greece and Bulgaria</td>
<td>Results revealed that perceived service quality among customers of Greek banks is more favourable than in Bulgaria</td>
</tr>
</tbody>
</table>

Other studies include:

Bloemer et al. provided a model of the influence of mental image, service quality, and customer satisfaction on customer’s loyalty. The findings indicated that mental image had an indirect effect through the service quality on loyalty. However, the quality of service affected both directly and indirectly (through satisfaction) on loyalty. Moreover, it was found that the reputation and position in the market were relatively important stimuli affecting loyalty to bank services (Bloemer et al., 1998).

Caruana’s study on the relationship between service quality, customer satisfaction, and loyalty of service in the Maltese banks concluded that customer satisfaction played the role of a mediator of the effects of service quality on service loyalty. In fact, the quality of services affected service loyalty through the customer satisfaction. In addition, the results showed that the quality of services was an important input of customer satisfaction and explained 53% of the variance (Caruana, 2002).

Yang et al. have presented a model of the relationship between service quality and reputation of the bank in their study. According to the researchers, the five dimensions of service quality had a direct impact on the bank’s reputation. Moreover, according to the findings, bank reputation played an important role in determining the customers’
purchase behaviour, repurchase behaviour, and loyalty. The importance of this issue in the banking industry is much higher because the service quality could not be properly measured before the purchase (Wang et al., 2003).

Chakravarty et al. carried out a study on the behaviour of customers leaving in the American Bank and found that there was a significant negative relationship between dimensions of service quality, responsiveness, reliability, empathy, and the willingness of customers to leave the bank. Their research at the Indian banks showed that the concept of service quality in developing countries is a multidimensional construct. In fact, the research clearly showed that the SERVQUAL model provided more diagnostic information regarding service quality gaps to the scale Seroperf (Chakravarty et al., 2004).

SERVQUAL model was used to measure the quality of banking services in most researches. Therefore, the expectations and perceptions of customers were just examined on the qualitative elements in banks, and dimensions with the highest gap between expectations and perceptions were discussed and studied. However, another important issue is that the power to prevent poor quality of banking services before they occur, repetition rate of poor quality of banking services in a qualitative element, and intensity of dissatisfaction that results from the problem of a qualitative element should be considered. Thus, FMEA technique has achieved great and important implications with regard to this approach in the promotion of products quality. However, its use has been paid a little attention in services, above descriptions can provide more precise basis for the development of services quality improvement programs in banks. Due to the lack of research in the field of banking services using failure analysis techniques, this technique history would be first provided and then a few studies conducted by this technique will be reviewed. The studies conducted on the area of FMEA in the country are as follows:

Karimi and Sadrabadi’s study assessed the quality of university banking services with 384 students who were selected as the sample of the study. He examined the status of university education for five dimensions (Takloo and Sadrabadi, 2013).

Heidary et al. conducted a study to identify and control hazards in the production halls of a pharmaceutical company through FMEA method. The results showed that although seemingly and at a superficial glance the pharmaceutical industry may seem a safe industry, many hazards exist in the working environment of such industries that may cause accidents, which are sometimes irreversible. According to the study findings, the following cases are recommended:

1. preparation and implementation of comprehensive guidelines for regular and periodic inspection of devices and systems in order to troubleshoot, identify, and evaluate hazards and their effects

2. preparation and implementation of comprehensive programs for the maintenance of systems

3. preparation and implementation of comprehensive banking targeted programs (Heidary et al., 2006).

Zanjirchi and Sayyadi provided a new methodology for using FMEA technique in order to reduce the risk of libraries qualitative errors and the results were applied to develop solutions to improve quality. Therefore, the errors in the qualitative components of
libraries were identified and evaluated by the criterion of risks priority that was obtained from the product of three criteria of “occurrence probability”, and “severity of error”, and “capability of prevention before the occurrence” [Zabirchi and Sayyadi, (2011), pp.57–61].

2.6 Prioritisation of banking service quality items in a fuzzy environment

There have been lots of discussions saying that risk factors (occurrence of failure O, severity of failure S, and detection capability of failure D) are not easy to evaluate precisely. Since verbal evaluation is done by individuals approximately, it could be said that triangular and trapezoidal membership functions is suitable to confront the ambiguity in these evaluations and efforts for achieving more exact values are impossible and unnecessary (Delgado, 1998). Some researchers have shown that Fuzzy membership function can reflect the relative importance of verbal concepts in our minds (Dyer and Sarin, 1979). Thus, we can follow the fuzzy membership function to convert verbal concepts into numeral ones in interval scale. Table 1 shows the verbal concepts and corresponding fuzzy numbers which are used to evaluate the banking service qualitative factors in this research. These concepts and their corresponding fuzzy numbers which are similar to the concepts in traditional FMEA are based on study of Wang et al. in 2009. However in the present study, these concepts have been attributed to the fuzzy triangular-trapezoidal numbers which are superior to the definite numbers.

Table 2 Verbal terms and fuzzy numbers for evaluation of banking services quality items

<table>
<thead>
<tr>
<th>Occurrence of failure</th>
<th>Severity of failure</th>
<th>Detection capability of failure</th>
</tr>
</thead>
<tbody>
<tr>
<td>Verbal term</td>
<td>Fuzzy number</td>
<td>Verbal term</td>
</tr>
<tr>
<td>Very high</td>
<td>(8, 9, 10, 10)</td>
<td>High</td>
</tr>
<tr>
<td>High</td>
<td>(6, 7, 8, 9)</td>
<td>Very high</td>
</tr>
<tr>
<td>Medium</td>
<td>(3, 4, 7, 6)</td>
<td>High</td>
</tr>
<tr>
<td>Low</td>
<td>(1, 2, 4, 3)</td>
<td>Very high</td>
</tr>
<tr>
<td>Very low</td>
<td>(1, 1, 2)</td>
<td>High</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Very low</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Trivial</td>
</tr>
</tbody>
</table>

The traditional FMEA suffers from several shortcomings, most importantly it was criticised because it did not consider the relative important of risk factors (Tay and Lim, 2010), and in other words, the same weight value was assumed for each of those factors. In order to solve this problem, in present study the relative importance of risk factors is calculated. Since it is not easy to evaluate risk factors, we will use verbal terms and their corresponding fuzzy numbers to evaluate relative important of weight of risk factors. Those numbers and concepts are summarised in Table 2.
Table 3  Fuzzy weights for relative importance of risk factors

<table>
<thead>
<tr>
<th>Verbal terms</th>
<th>Fuzzy number</th>
</tr>
</thead>
<tbody>
<tr>
<td>Very low</td>
<td>(0, 0, 0.25)</td>
</tr>
<tr>
<td>Low</td>
<td>(0, 0.25, 0.5)</td>
</tr>
<tr>
<td>Medium</td>
<td>(0.25, 0.5, 0.75)</td>
</tr>
<tr>
<td>High</td>
<td>(0.5, 0.75, 1)</td>
</tr>
<tr>
<td>Very high</td>
<td>(0.75, 1, 1)</td>
</tr>
</tbody>
</table>

Assume that \( n \) failure items \( FM_1, \ldots, FM_n \) that have been evaluated by an FMEA team including members \( TM_1, \ldots, TM_m \) are evaluated and ranked.

Consider \( \tilde{R}_i^O = (R_{iL}^O, R_{iM}^O, R_{iU}^O) \) and \( \tilde{R}_i^S = (R_{iL}^S, R_{iM}^S, R_{iU}^S) \) as the fuzzy degree of \( i \)th failure item in the risk factors, O, S, and D, respectively. Furthermore, consider \( \tilde{w}_j^O = (w_{jL}^O, w_{jM}^O, w_{jU}^O) \), \( \tilde{w}_j^S = (w_{jL}^S, w_{jM}^S, w_{jU}^S) \) and \( \tilde{w}_j^D = (w_{jL}^D, w_{jM}^D, w_{jU}^D) \) as the fuzzy weights of three risk factors which have been presented by \( j \)th member of FMEA team \( TM_j \), and consider \( h_j (j = 1, \ldots, m) \) as the relative importance of each member’s weight in FMEA team such that \( \sum_{j=1}^{m} h_j = 1 \) and \( h_j > 0 (j = 1, \ldots, m) \) is satisfied.

Based on the above assumptions, \( n \) failure items can be ranked using the following steps.

Step 1  Obtain sum of ideas of members of FMEA team is using relations 1 to 6.

Relation (1):  
\[
\tilde{R}_i^O = \left( \sum_{j=1}^{m} h_j R_{jL}^O, \sum_{j=1}^{m} h_j R_{jM}^O, \sum_{j=1}^{m} h_j R_{jU}^O \right), i = 1, \ldots, n,
\]

Relation (2):  
\[
\tilde{R}_i^S = \left( \sum_{j=1}^{m} h_j R_{jL}^S, \sum_{j=1}^{m} h_j R_{jM}^S, \sum_{j=1}^{m} h_j R_{jU}^S \right), i = 1, \ldots, n,
\]

Relation (3):  
\[
\tilde{R}_i^D = \left( \sum_{j=1}^{m} h_j R_{jL}^D, \sum_{j=1}^{m} h_j R_{jM}^D, \sum_{j=1}^{m} h_j R_{jU}^D \right), i = 1, \ldots, n,
\]

Relation (4):  
\[
\tilde{w}_j^O = \left( \sum_{j=1}^{m} h_j w_{jL}^O, \sum_{j=1}^{m} h_j w_{jM}^O, \sum_{j=1}^{m} h_j w_{jU}^O \right), j = 1, \ldots, m,
\]

Relation (5):  
\[
\tilde{w}_j^S = \left( \sum_{j=1}^{m} h_j w_{jL}^S, \sum_{j=1}^{m} h_j w_{jM}^S, \sum_{j=1}^{m} h_j w_{jU}^S \right), j = 1, \ldots, m,
\]

Relation (6):  
\[
\tilde{w}_j^D = \left( \sum_{j=1}^{m} h_j w_{jL}^D, \sum_{j=1}^{m} h_j w_{jM}^D, \sum_{j=1}^{m} h_j w_{jU}^D \right), j = 1, \ldots, m,
\]

Such that  
\[
\tilde{R}_i^O = (R_{iL}^O, R_{iM}^O, R_{iU}^O), \tilde{R}_i^S = (R_{iL}^S, R_{iM}^S, R_{iU}^S), \tilde{R}_i^D = (R_{iL}^D, R_{iM}^D, R_{iU}^D),
\]

are the sum of degree of failure occurrence (O), severity of failure (S) and detection capability of failure (D) for failure item \( FM_i \), and  
\[
\tilde{w}_j^O = (w_{jL}^O, w_{jM}^O, w_{jU}^O), \tilde{w}_j^S = (w_{jL}^S, w_{jM}^S, w_{jU}^S), \tilde{w}_j^D = (w_{jL}^D, w_{jM}^D, w_{jU}^D),
\]

are the sum of Fuzzy weights of three risk factors O, S and D, respectively.
Step 2 Determine fuzzy risk priority number (FRPN) for each banking service quality item using the following equation.

Relation (7) for geometric mean:

$$FRPN_i = \left( \bar{R}^I_i \right)^{\frac{\hat{\alpha}}{3\hat{\alpha}}} \times \left( \bar{R}^L_i \right)^{\frac{\hat{\alpha}}{3\hat{\alpha} + \hat{\alpha}}} \times \left( \bar{R}^D_i \right)^{\frac{\hat{\alpha}}{3\hat{\alpha} + \hat{\alpha} + \hat{\alpha}}}, \ i = 1,\ldots,n.$$  

Since FRPN are fuzzy numbers, they can be calculated using Alpha-cut sets.

Step 3 Determine Alpha-cut sets of FRPN for each failure items of banking service quality is by solving the following LP models:

Model (1):

$$\begin{align*}
\min & \quad \prod_{i=1}^{n} (\bar{x}_i) \sum_{j=1}^{w_j} \\
\text{subject to} & \quad (w_i)_{\alpha} \leq w_i \leq (w_i)_{\alpha}, \quad i = 1,\ldots,n, \\
& \quad (x_i)_{\alpha} \leq x_i \leq (x_i)_{\alpha}, \quad i = 1,\ldots,n,
\end{align*}$$

Model (2):

$$\begin{align*}
\max & \quad \prod_{i=1}^{n} (x_i) \sum_{j=1}^{w_j} \\
\text{subject to} & \quad (w_i)_{\alpha} \leq w_i \leq (w_i)_{\alpha}, \quad i = 1,\ldots,n, \\
& \quad (x_i)_{\alpha} \leq x_i \leq (x_i)_{\alpha}, \quad i = 1,\ldots,n,
\end{align*}$$

Given the nonlinearity of the above models, they will be rewritten as follow:

Model (3):

$$\begin{align*}
\min & \quad \exp \left( \sum_{j=1}^{w_j} \frac{w_j \ln (x_i)_{\alpha}}{\alpha} \right) \\
\text{subject to} & \quad (w_i)_{\alpha} \leq w_i \leq (w_i)_{\alpha}, \quad i = 1,\ldots,n,
\end{align*}$$

Model (4):

$$\begin{align*}
\max & \quad \exp \left( \sum_{j=1}^{w_j} \frac{w_j \ln (x_i)_{\alpha}}{\alpha} \right) \\
\text{subject to} & \quad (w_i)_{\alpha} \leq w_i \leq (w_i)_{\alpha}, \quad i = 1,\ldots,n,
\end{align*}$$

In the above models, $\exp (\ )$ is an exponential function.

Based on the above models, if $\ z = \sqrt[3]{\frac{1}{\sum_{j=1}^{w_j}}}$ and $u_i = zw_{ij} = 1,\ldots,n$, models 3 and 4 become LP models below which can be solved easily.
Min  \[ z_1 = u_1 \ln (R^O)^L_{\alpha} + u_2 \ln (R^S)^L_{\alpha} + u_3 \ln (R^D)^L_{\alpha} \]
\[ s.t. \quad u_1 + u_2 + \ldots + u_n = 1, \quad i = 1, \ldots, n, \]
Model (5):
\[ (w^O)^L_{\alpha} \cdot z \leq u_1 \leq (w^O)^U_{\alpha} \cdot z, \quad i = 1, \ldots, n, \]
\[ (w^S)^L_{\alpha} \cdot z \leq u_2 \leq (w^S)^U_{\alpha} \cdot z, \quad i = 1, \ldots, n, \]
\[ (w^D)^L_{\alpha} \cdot z \leq u_3 \leq (w^D)^U_{\alpha} \cdot z, \quad i = 1, \ldots, n, \]
\[ z \geq 0, \]
Max  \[ z_2 = u_1 \ln (R^O)^U_{\alpha} + u_2 \ln (R^S)^U_{\alpha} + u_3 \ln (R^D)^U_{\alpha} \]
\[ s.t. \quad u_1 + u_2 + \ldots + u_n = 1, \quad i = 1, \ldots, n, \]
Model (6):
\[ (w^O)^L_{\alpha} \cdot z \leq u_1 \leq (w^O)^U_{\alpha} \cdot z, \quad i = 1, \ldots, n, \]
\[ (w^S)^L_{\alpha} \cdot z \leq u_2 \leq (w^S)^U_{\alpha} \cdot z, \quad i = 1, \ldots, n, \]
\[ (w^D)^L_{\alpha} \cdot z \leq u_3 \leq (w^D)^U_{\alpha} \cdot z, \quad i = 1, \ldots, n, \]
\[ z \geq 0, \]

Such that  \[ \ln(R^O)^L_{\alpha}, \ln(R^O)^U_{\alpha}, \ln(R^S)^L_{\alpha}, \ln(R^S)^U_{\alpha}, \ln(R^D)^L_{\alpha}, \ln(R^D)^U_{\alpha} \] and  \[ \ln(R^O)^L_{\alpha}, \ln(R^O)^U_{\alpha}, \ln(R^S)^L_{\alpha}, \ln(R^S)^U_{\alpha}, \ln(R^D)^L_{\alpha}, \ln(R^D)^U_{\alpha} \] are logarithms of  \[ [(R^O)^L_{\alpha}, (R^O)^U_{\alpha}], [(R^S)^L_{\alpha}, (R^S)^U_{\alpha}], [(R^D)^L_{\alpha}, (R^D)^U_{\alpha}] \] respectively, which  \[ \tilde{R}^O, \tilde{R}^S, \tilde{R}^D \], are the Alpha-cut sets of occurrence of failure (O), severity of failure (S) and detection capability of failure (D), for each failure item  \[ FM_i \] (1, \ldots, \( n \)). Also  \[ [(w^O)^L_{\alpha}, (w^O)^U_{\alpha}], [(w^S)^L_{\alpha}, (w^S)^U_{\alpha}], [(w^D)^L_{\alpha}, (w^D)^U_{\alpha}] \] and  \[ [(w^O)^L_{\alpha}, (w^O)^U_{\alpha}] \] are the Alpha-cut sets of the summed weights of risk factors  \[ \tilde{w}^O, \tilde{w}^S \] and  \[ \tilde{w}^D \], respectively.

The above LP models must be solved for each failure item. Consider  \[ z_1^* \] and  \[ z_2^* \] as the appropriate answers for models 5 and 6. If this case,  \[ (FRPN_i)^L_{\alpha} = \exp(z_1^*), (FRPN_i)^U_{\alpha} = \exp(z_2^*) \]. With different values of Alpha, different Alpha-cut sets will be obtained for FRPNi, which can be expressed as follow:

Relation (7):  \[ FRPN_i = \bigcup_{\alpha} \alpha \{ (FRPN_i)^L_{\alpha}, (FRPN_i)^U_{\alpha} \}, \quad 0 < \alpha \leq 1, \]

Step 4 The failure items should be categorised based on the  \[ \tilde{R} \]. Since the  \[ \tilde{R} \] values for each item and in each Alpha-cut are interval numbers, in the present research, Yue (2010) model has been used in order to categorise those interval numbers. The basis of this method is degree of greatness probability of one interval number comparing to another one. If we consider a and b as two interval numbers  \[ a = [a', a''], b = [b', b''] \] so that  \[ l_a = a'' - a' \] and  \[ l_b = b'' - b' \], the degree of greatness possibility a and b is defined as:

Relation (8):  \[ p(a \geq b) = \max \left\{ 1 - \max \left( \frac{b'' - a'}{l_a + l_b}, \sigma \right), \sigma \right\} \]
In order to rank the interval risk such as $\overline{R}_j = [R_j^l, R_j^u]$ ($j = 1, 2, \ldots, n$), we should first compare each $\overline{R}_j = [R_j^l, R_j^u]$ with all $\overline{R}_i = [a_i^l, a_i^u]$ ($j = 1, 2, \ldots, n$), for each Alpha-cuts using relation (8). For convenience, we consider $p^\alpha_i$ as the degree of greatness possibility for $R^\alpha_i$ on $R^\alpha_j$ in Alpha-cut, i.e., $p^\alpha_i = p(R^\alpha_i \geq R^\alpha_j)$. Then we form the matrix $P^\alpha = (p^\alpha_{ij})_{n \times n}$ for each Alpha-cut so that relations $p^\alpha_{ij} \geq o, p^\alpha_{ij} + p^\alpha_{ji} = 1, p^\alpha_{ji} = \frac{1}{2} p^\alpha_{ij}, i, j = 1, 2, \ldots, n.$ are satisfied in this matrix. Then calculate the sum of the elements in each line of the matrix using relation (9).

Relation (9): $p^\alpha_i = \sum_{j=1}^{n} p^\alpha_{ij}, i = 1, 2, \ldots, n.$

Finally the degree of greatness probability for each failure item is calculated using the following relation.

Relation (10): $p_i = \sum_{\alpha=0}^{1} p^\alpha_i, i = 1, 2, \ldots, n.$

Ultimately, the failure items of banking service quality are ranked in descending manner of $p_i$. In other word, the item with higher $p_i$ will have higher rank.

3 Methodology

The research approach is applied, the strategy is quantitative, and the runtime of the study is one-sectional. Procedures of the FMEA were used in the implementation of banking services quality as follows:

Step 1 to define qualitative failures in the system: the first step in FMEA is to determine potential cases of failure that the system is encountered. Bank service quality items were identified based on SERVQUAL model. Bank service quality has 26 items and 5 dimensions based on the model.

Step 2 To measure triple indices of error priority: The population of the study includes all clients attending the Central Melli Bank of Rafsanjan. According to the unlimited sample size, 368 questionnaires (in three forms) were distributed, of which 351 questionnaires were returned (rate of return = 0.95). The questionnaires were distributed among diverse audiences based on the required information.

a To measure the severity of failure: a questionnaire was design and the clients were asked to respond to them in order to the failure to measure the severity of the impact of failures on the customers’ satisfaction.
To measure the probability of failure: in order to estimate the probability of failures in bank service quality, respondents were asked to report the percentage of times that faced failure during their reference at the second part of the above-mentioned questionnaire.

to measure the detection and prevention capabilities: the related questions were asked from the bank experts due to the specialised nature of this questionnaire.

Step 3 Calculate of (FRPN): by multiplying of occurrence of failure, severity of failure and detection capability of failure, the RPN for each banking service quality failure will be determined in form of Fuzzy number based on non-provision of customer’s expectation.

Step 4 the proposed model of the research: in this study using FMEA fuzzy model calculated value of FRPN. After calculating the values of FRPN, in order to prioritise the failure items will be used of Yue (2010) method.

At this point, to rate or prioritise the failure items regardless of their dimensions provides a general map of the improvement prioritised sequence. However, since considering a large number of failure variables is not possible to improve quality through majority of banks in a short time and with the limited resources, therefore, it is necessary to determine and introduce a number of banks who have the greatest impact to achieve the banks to the desired service quality. This was performed via Pareto law.

Pareto law knows 80% of the effects resulting from 20% of the causes. According to this principle, attention to this 20% can have the greatest effect or improvement in 80% of the causes.

4 Findings

This section presents the results of the implementation of the proposed research model to examine the items of bank service quality in Rafsanjan Central Melli Bank.

The present article used Hybrid models of Wang and Yue for evaluate quality of banking service risks. According to Pareto chart, 20% of the factors that have caused 80% of failures can be recognised. The results of the assessment and prioritisation of service quality items of Rafsanjan Melli Bank based on fuzzy FMEA approach suggests that the most important items of bank failures in service quality based on the Pareto principle, including 20% of the factors that have caused 80% of failures are as follows:

1. lack of a good place to park the customers’ car
2. lack of appropriate levels of bank interest rates
3. low speed of the bank employees to perform their work in a timely manner.

Based on the results obtained in this study, the following suggestions can be addressed to increase the service quality:

• to train employees to improve their performance quickly
• to change the location of bank or create a location for car park.
<table>
<thead>
<tr>
<th>Row</th>
<th>Failure item</th>
<th>Detection</th>
<th>Severity</th>
<th>Occurrence</th>
<th>$P_i$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Q1</td>
<td>Dissatisfaction with the beauty and attractiveness aspect of bank (6.8, 5.6, 4.9)</td>
<td>(4.50, 6.89, 7.3)</td>
<td>(3.66, 5.78, 7.77, 4.09)</td>
<td>58.21053</td>
<td></td>
</tr>
<tr>
<td>Q2</td>
<td>Lack of beauty and charm of the employees' dressing (5.45, 4.45, 6.45)</td>
<td>(6.54, 7.43, 4.11)</td>
<td>(7.13, 7.80, 5.14, 4.95)</td>
<td>46.76537</td>
<td></td>
</tr>
<tr>
<td>Q3</td>
<td>Dissatisfaction with the uniform among the staff (5.0, 5.5, 4.90)</td>
<td>(5.11, 4.90, 3.10)</td>
<td>(6.12, 5.26, 4.19, 3.35)</td>
<td>56.50668</td>
<td></td>
</tr>
<tr>
<td>Q4</td>
<td>Lack of welfare facilities in the bank (hygiene service, table and chairs, hot and cold air conditioning) (6.4, 5.4, 4.4)</td>
<td>(7.04, 6.10, 5.15)</td>
<td>(7.45, 6.66, 5.44, 4.52)</td>
<td>67.31149</td>
<td></td>
</tr>
<tr>
<td>Q5</td>
<td>Lack of a proper location to park the customers' cars (5.45, 4.45, 3.45)</td>
<td>(7.12, 6.20, 5.22)</td>
<td>(7.32, 6.57, 5.40, 4.48)</td>
<td>117.262</td>
<td></td>
</tr>
<tr>
<td>Q6</td>
<td>Difficulty in access to the required means of the customers (6.3, 5.3, 4.3)</td>
<td>(6.71, 5.78, 4.82)</td>
<td>(7.06, 6.29, 5.20, 4.32)</td>
<td>65.26654</td>
<td></td>
</tr>
<tr>
<td>Q7</td>
<td>Low speed of bank employees to do the related works timely (6.05, 5.05, 4.05)</td>
<td>(6.74, 5.78, 4.82)</td>
<td>(7.40, 6.61, 5.43, 4.50)</td>
<td>83.64207</td>
<td></td>
</tr>
<tr>
<td>Q8</td>
<td>Excessive delay in transferring credits to customers (6.6, 5.6, 4.6)</td>
<td>(6.88, 5.94, 4.97)</td>
<td>(6.96, 6.15, 4.99, 4.09)</td>
<td>70.09363</td>
<td></td>
</tr>
<tr>
<td>Q9</td>
<td>No proper working of the employees (6, 5, 4)</td>
<td>(6.43, 5.48, 4.54)</td>
<td>(7.18, 6.36, 5.12, 4.19)</td>
<td>73.30627</td>
<td></td>
</tr>
<tr>
<td>Q10</td>
<td>Inappropriate interest rate of banks (6.2, 5.2, 4.2)</td>
<td>(6.40, 5.43, 4.48)</td>
<td>(6.50, 5.64, 4.51, 3.66)</td>
<td>93.99481</td>
<td></td>
</tr>
<tr>
<td>Q11</td>
<td>Lack of fulfillment of bank promises to pay interest and facilities (6.7, 5.7, 4.7)</td>
<td>(6.25, 5.29, 4.38)</td>
<td>(6.10, 5.25, 4.28, 3.49)</td>
<td>65.93016</td>
<td></td>
</tr>
<tr>
<td>Q12</td>
<td>Insufficient number of bank employees to deliver services (6.65, 5.65, 4.65)</td>
<td>(6.53, 5.59, 4.65)</td>
<td>(6.79, 5.97, 4.81, 3.91)</td>
<td>49.25799</td>
<td></td>
</tr>
<tr>
<td>Q13</td>
<td>Lack of easy access to customer account status (6.45, 5.45, 4.45)</td>
<td>(6.61, 5.56, 4.71)</td>
<td>(7.18, 6.39, 5.30, 4.42)</td>
<td>51.89744</td>
<td></td>
</tr>
<tr>
<td>Q14</td>
<td>Lack of necessary awareness (6.4, 5.4, 4.4)</td>
<td>(6.96, 6.03, 5.10)</td>
<td>(7.29, 6.54, 5.42, 4.53)</td>
<td>51.87179</td>
<td></td>
</tr>
<tr>
<td>Q15</td>
<td>Lack of timely presence of employees in the workplace (5.9, 4.9, 3.9)</td>
<td>(6.74, 5.82, 4.9)</td>
<td>(6.32, 5.51, 4.40, 3.56)</td>
<td>46.40003</td>
<td></td>
</tr>
<tr>
<td>Q16</td>
<td>Linger for delivering services (5.6, 4.6, 3.6)</td>
<td>(6.02, 5.11, 4.26)</td>
<td>(6.13, 5.34, 4.39, 3.61)</td>
<td>66.698</td>
<td></td>
</tr>
<tr>
<td>Q17</td>
<td>Lack of staff expertise in their respective field of work (6.473, 5.473, 4.473)</td>
<td>(6.09, 5.13, 4.25)</td>
<td>(6.26, 5.41, 4.33, 3.51)</td>
<td>41.52427</td>
<td></td>
</tr>
<tr>
<td>Q18</td>
<td>Lack of clear guidelines, such as bank facilities and ... (6.75, 5.75, 4.75)</td>
<td>(6.46, 5.52, 4.57)</td>
<td>(7.12, 6.29, 5.04, 4.12)</td>
<td>65.83386</td>
<td></td>
</tr>
<tr>
<td>Q19</td>
<td>Failure to observe the staff's propriety and respect in dealing with colleagues (6.5, 5.9, 4.9)</td>
<td>(6.88, 5.95, 4.97)</td>
<td>(7.56, 6.79, 5.60, 4.65)</td>
<td>48.82452</td>
<td></td>
</tr>
<tr>
<td>Q20</td>
<td>Failure to observe courtesy and respect in dealing with clients (7.2, 6.2, 5.2)</td>
<td>(7.04, 6.14, 5.2)</td>
<td>(7.00, 6.26, 5.18, 4.31)</td>
<td>50.20408</td>
<td></td>
</tr>
<tr>
<td>Q21</td>
<td>Insufficient attention of bank employees to customers to solve their problems (6.05, 5.05, 4.05)</td>
<td>(5.62, 4.66, 3.80)</td>
<td>(5.82, 4.93, 3.85, 3.04)</td>
<td>57.06465</td>
<td></td>
</tr>
<tr>
<td>Q22</td>
<td>Lack of the staff's compassion at a time when they are not able to solve customer problems (5.8, 4.8, 3.8)</td>
<td>(6.2, 5.24, 4.33)</td>
<td>(7.23, 6.44, 5.30, 4.38)</td>
<td>56.5109</td>
<td></td>
</tr>
<tr>
<td>Q23</td>
<td>Lack of easy access to the administration head (6.5, 5.5, 4.5)</td>
<td>(6.45, 5.48, 4.54)</td>
<td>(6.43, 5.53, 4.31, 3.42)</td>
<td>69.80144</td>
<td></td>
</tr>
<tr>
<td>Q24</td>
<td>Lack of access to bank in holidays (access to connection window and internet communication) (6.7, 5.7, 4.7)</td>
<td>(6.54, 5.58, 4.64)</td>
<td>(7.21, 6.44, 5.29, 4.40)</td>
<td>42.5566</td>
<td></td>
</tr>
<tr>
<td>Q25</td>
<td>Lack of the security facilities equipment in banks (6.55, 5.55, 4.55)</td>
<td>(6.94, 6.02, 5.07)</td>
<td>(7.38, 6.60, 5.45, 4.55)</td>
<td>63.59878</td>
<td></td>
</tr>
<tr>
<td>Q26</td>
<td>Non-confidentiality of customer accounts (6.65, 5.65, 4.65)</td>
<td>(6.41, 5.46, 4.54)</td>
<td>(6.45, 5.58, 4.41, 3.55)</td>
<td>42.59643</td>
<td></td>
</tr>
</tbody>
</table>
Table 5  Rating RPN values of bank service quality items regardless of dimensions

<table>
<thead>
<tr>
<th>Dimensions</th>
<th>$P_i$</th>
<th>Percent of $P_i$</th>
<th>Cumulative percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Q5</td>
<td>117.262</td>
<td>0.071305</td>
<td>0.071305</td>
</tr>
<tr>
<td>Q10</td>
<td>93.99481</td>
<td>0.057157</td>
<td>0.128462</td>
</tr>
<tr>
<td>Q7</td>
<td>83.64207</td>
<td>0.050862</td>
<td>0.179324</td>
</tr>
<tr>
<td>Q8</td>
<td>80.93672</td>
<td>0.049216</td>
<td>0.22854</td>
</tr>
<tr>
<td>Q8</td>
<td>70.06936</td>
<td>0.042608</td>
<td>0.271149</td>
</tr>
<tr>
<td>Q4</td>
<td>69.80144</td>
<td>0.042445</td>
<td>0.313594</td>
</tr>
<tr>
<td>Q23</td>
<td>67.31149</td>
<td>0.040931</td>
<td>0.354525</td>
</tr>
<tr>
<td>Q16</td>
<td>66.6989</td>
<td>0.040559</td>
<td>0.395084</td>
</tr>
<tr>
<td>Q11</td>
<td>65.93016</td>
<td>0.040033</td>
<td>0.435175</td>
</tr>
<tr>
<td>Q8</td>
<td>65.83386</td>
<td>0.039688</td>
<td>0.514895</td>
</tr>
<tr>
<td>Q6</td>
<td>65.26654</td>
<td>0.039688</td>
<td>0.584586</td>
</tr>
<tr>
<td>Q25</td>
<td>63.59878</td>
<td>0.038674</td>
<td>0.623666</td>
</tr>
<tr>
<td>Q1</td>
<td>58.21053</td>
<td>0.035397</td>
<td>0.658029</td>
</tr>
<tr>
<td>Q21</td>
<td>57.06465</td>
<td>0.034363</td>
<td>0.692387</td>
</tr>
<tr>
<td>Q22</td>
<td>56.5109</td>
<td>0.034357</td>
<td>0.723945</td>
</tr>
<tr>
<td>Q13</td>
<td>51.89744</td>
<td>0.031558</td>
<td>0.755487</td>
</tr>
<tr>
<td>Q14</td>
<td>51.87179</td>
<td>0.031543</td>
<td>0.786016</td>
</tr>
<tr>
<td>Q20</td>
<td>50.20408</td>
<td>0.030528</td>
<td>0.816375</td>
</tr>
<tr>
<td>Q12</td>
<td>49.92579</td>
<td>0.030528</td>
<td>0.844812</td>
</tr>
<tr>
<td>Q15</td>
<td>46.40003</td>
<td>0.028215</td>
<td>0.873027</td>
</tr>
<tr>
<td>Q19</td>
<td>44.82452</td>
<td>0.027257</td>
<td>0.900284</td>
</tr>
<tr>
<td>Q26</td>
<td>42.59643</td>
<td>0.025902</td>
<td>0.926187</td>
</tr>
<tr>
<td>Q24</td>
<td>42.55566</td>
<td>0.025877</td>
<td>0.952064</td>
</tr>
<tr>
<td>Q17</td>
<td>41.52427</td>
<td>0.02525</td>
<td>1</td>
</tr>
</tbody>
</table>

Figure 1  Pareto chart (see online version for colours)
5 Conclusions

The given paper focuses on measuring service quality in Melli banking. The authors’ goal is to offer new method for service quality measurement of banking. Most studies have used of SERVQUAL model to measure the quality of the banks. All studies have examined the gap between expectations and perceptions. Then rank them according to their maximum gap. But FMEA method, of three factors (occurrence of failure, severity of failure and detectability of failure) will be used to measure the quality of banking services. Therefore, the FMEA technique has various important uses in promotion of products quality. However, less attention has been paid to it in services area, but with above explanations it can provide a more precise basis for development of service quality improvement programs. On the other, Reviewing the literature showed that in the FMEA Technique, the weight of risk factors are not considered, in other words, the Equal weight value are assumed for each of those factors. However it could not be used in practical application of FMEA. In order to remove this weakness, much research has been done. we used of fuzzy FMEA models. Ratings actual and potential failures in service quality of Rafsanjan Melli Bank gave their improvement priority well. These priorities are provided based on the creation of injury in order to meet customers’ needs. These data can form the basis of the program to improve the quality of banking services. In the case of strategies based on the priority of each dimension, ranking the failures on those dimensions would be the basis of sequence of the performance of improvement programs and otherwise, the overall presented ranking, which will guide the decision-makers and managers.

References


