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Improving the quality of the credit authorization process

A quantitative approach

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Abstract *This paper proposes that the quality of a company's authorization system should be measured by two major considerations. First, the system should enhance the quality of customer service by reducing the waiting time at the point of sale. Second, it should reduce the risk of accepting transactions of bad credit. In this paper, a major credit card company is used to demonstrate how the credit authorization process can be improved using a quantitative approach. Opportunities for quality improvement were first identified through brainstorming sessions with top management, using quality improvement tools. A new sampling inspection scheme was then developed, based on analysis of the risk of requests for transactions in different industries. With the new inspection scheme, the total inspection cost was significantly reduced. A queuing model was then used to redesign the authorization process. Finally, a simulation model was used to test and evaluate the new process design. As a result of these improvements, it was determined that more than US$2.5 million was saved annually and authorization efficiency was improved by more than 40 per cent.*

Introduction

The credit card industry has been steadily growing over the last 50 years, with major corporations such as AT&T, GE and GM setting up their own credit card operations. Due to the rapid expansion of the industry, credit card companies need to maintain a high level of service quality to stay competitive and differentiate themselves from others.

A credit card system should comprise at least three major components, namely, credit application approval, credit authorization and posting of customer payment. The aim of the credit application approval process is to prevent the acceptance of high-risk applications and to accept low-risk applications. The aim of the credit authorization process is to deny fraudulent or bad transactions while approving good transactions when charge requests are initiated at the point of sale. This process is particularly important for protecting cardholders who have lost their cards but have not yet reported the loss to the card center. Also, it will capture and disallow transactions that are initialized by fraudulent card owners.

Although service quality can be measured according to the different stages of the card processing system, such as quick and accurate approval, production and mailing out of new credit cards etc., one key measurement is the quality of the authorization process. From the customer's point of view, a high-quality authorization process should result in:

(1) Effective credit control:
- automatic denial of fraudulent or bad transactions; and
- approval of good transactions.

(2) Efficient authorization procedure:
- minimum voice contact with the authorizers; and
- minimum waiting time at the point of sale.

One major issue related to the credit authorization process is the possibility of long waiting times at the point of sale during peak hours, which has a negative effect on the quality of service. In addition, shops may request for other credit cards. Therefore, the challenge is to develop an authorization process that will reduce the waiting time of cardholders while maintaining a high level of credit control.

Most of the literature on credit card service quality is devoted to the development of effective and efficient credit management and card approval processes rather than the authorization process at the point of sales. Rosenberg and Gleit (1994) have written a review of credit management using quantitative methods. They surveyed the use of various qualitative approaches, such as discriminant analysis, decision trees, and expert systems for static decisions, dynamic programming, linear programming, and the Markov chains for dynamic decision models. Doronsoro *et al.* (1997) have presented an on-line system for fraud detection in credit card operations using a neural network approach. Eisenbeis (1996) has written a review of recent developments in the application of credit-scoring techniques in the evaluation of commercial loans. Crook *et al.* (1995) have presented a detailed comparison between a credit scoring model with a credit performance model. Collier (1991) quantitatively related the customer's evaluation (perception) of service quality directly to the activities and performance criteria of the service delivery process for a credit card processing center. Vijay has done a comparison of neural networks and traditional linear scoring models, applying them to the credit union environment (Vijay *et al.*, 1996). Leonard (1995) presented a rule-based expert system to help alert financial institutions to the detection of fraudulent use of credit cards. While many researchers have spent tremendous effort in credit management using various quantitative techniques, they have focused mainly on the credit or card approval procedures or fraudulent detection using quantitative or rule-based decision approaches. No literature regarding the use of consecutive quantitative techniques to improve the card authorization process has been reported.

The objective of this paper is to demonstrate the successful use of quantitative techniques to improve the responsiveness and the reduction in waiting time of the overall credit authorization process, while maintaining an acceptable level of credit control. In this case, two major approaches, namely, sampling inspection and real time queue prevention have been used.

With the sampling inspection approach, transactions from low-risk industries, such as the restaurant industry, will be automatically approved to save the operation times. Though many major credit card companies match employee capacity and demand patterns with credit card authorizations, their approaches are more reactive. They usually allocate more staff to handle authorizations after a queue has been established. We have used a more preventive approach. Once the arrival rate is too high or the service rate is too low, more authorizers will be allocated. With this approach, the waiting time can be maintained at a desired level, and a long queue will not be established.

The paper is organized as follows. First, we provide a background of the study, and then describe the original authorization process in the following section. A description of the problem is then given, followed by a section on data collection and analysis. Finally, we discuss the process as it has been redesigned, and the implications of the new process for the quality of the authorization process. Operational costs saved are also presented and discussed.

Background

The company in this study is a multinational credit card company with a major operation established in Hong Kong. It has two major local authorization centers with hundreds of operating centers worldwide that are responsible for checking millions of transactions monthly.

Over the last few years, most of the improvements developed by the company for their authorization process were technology-driven (Rose, 1990). An expert system was developed to reduce the number of errors committed by the authorizers. Pattern recognition techniques were used to reduce credit and fraud losses. Fault-tolerant computers were installed to increase the reliability of communications. As a result, fraudulent or bad transactions could be detected more accurately and credit was controlled much more effectively.

More importantly, the company has maintained computer credit authorization interfaces with many service establishments. Utilization of these interfaces allowed charge requests to be automatically approved or denied at the point of sales without recourse to the formal authorization decision process. Hence, the average waiting time for cardholders at the point of sales was also reduced.

A new vision of the credit authorization system

However, to fully carry out the spirit of total quality management, the top management believes that the authorization system should be customer-driven rather than technology-driven, and that service quality should be defined by the customers rather than the company (Parasuraman *et al.*, 1985). Therefore, a new vision of the credit authorization system has been defined. First, the company has identified that both cardholders and service establishments are valued customers of the company and that their individual needs must be satisfied. Second, the company must make every effort to minimize bad debts due to fraudulent and bad transactions.

Most importantly, the company must minimize the inconvenience to the cardholders caused by the authorization decision process. From the customers' point of view, the two factors that cause them the most inconvenience are the waiting time at the point of sales and voice contact with the authorizers. These factors should be given top priority in improving the credit authorization system.

The current authorization process

Any charges requested by cardholders, also known as requests of charges (ROCs), currently must undergo several investigation procedures to assure that fraudulent and bad transactions are denied. First, ROCs go through a negative card check to see if the card has been canceled or stolen or if it has expired. If a card is determined to be a "negative" one, ROCs initialized by that card will be denied at the point of sales. Otherwise, they will be further investigated by a computerized risk management system to check the credit and spending pattern of the cardholder. The risk management system is developed based on statistical techniques. If a decision can be reached after this first investigation, no further investigation will be undertaken. Otherwise, ROCs will be sent to an expert system that is composed of a set of production rules. These rules are developed based on information obtained from the top performance authorizers. If no decision can be made at this stage, ROCs will be referred to authorizers who are well-trained operators responsible for detecting fraud or bad transactions (Figure 1). Cardholders will then be requested to talk to an authorizer to provide further information. This is referred to as a voice contact process.

Though ROCs take only a few seconds to go through the risk management system and the expert system, authorizers may spend from one or two minutes to several hours in making a decision. Therefore, authorization decisions can be delayed significantly once they are referred to an authorizer.

As a consequence of these delays, long referral queues may build up. This situation usually happens during the busiest periods, and is more serious during holidays, such as Christmas and New Year. The impact of a long referral queue is shown in Table I.

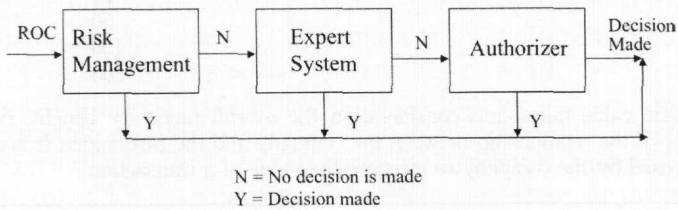

Figure 1. Flow chart of authorization process

Problem description

The original auto-approval system

To reduce the impact created by heavy referral transactions, some referrals are approved by the company automatically at the point of sales. The ROCs selected for auto-approval strategy are based on a net value, which is estimated by the risk management system. The net value is calculated by taking into consideration the value of the cardholders, the service establishments and, most importantly, the financial impact on the company. While the value of the cardholder was developed on the basis of his or her credit history, the value of the service establishment was developed on the basis of frequency of card service use.

Once the length of a referral queue reached ten ROCs waiting for authorizers' responses, ROCs below a certain value were automatically approved. The queue length was automatically updated through a telecommunications device. As the length of a referral queue increased, the threshold point for auto-approval was also increased in order to auto-approve more ROCs. However, the threshold would decrease as the length of the referral queue decreased (Table II). That is, credit control would be relaxed as the referral queue increased. Under this condition, transactions with higher benefit value, implying higher risk exposure, would be auto-approved.

Several deficiencies existed in the above authorization process. The cardholder might still have to suffer a long waiting period, because the referral

Table I.
The impact of long queue establishment

Operational impact	Service impact
Cardholders will have to wait for a longer time at the point of sale	The relationship between the credit company, cardholders and service establishments will be damaged
Authorizers will tend to loosen the credit control process to speed up authorization decisions	Credit control will be reduced
Auto-approval will have to be used to reduce the referral volume	Relatively high-risk transactions will be approved

Table II.
Threshold value table for automatic approval strategy

Queue length (people)	Benefit value
5-10	25
11-15	50
16-20	100
20-25	200

Notes: Benefit value takes into consideration the overall monetary benefit, risk exposure and the value of the relationship between the company and the cardholder. It is a special kind of unit used by the company to measure the value of a transaction volume control strategy only considered queue length, but not the number of authorizers available. For the same queue length, the waiting time of a cardholder depended very much on the number of authorizers available, which could be drastically different from one time to another. The original approach adjusted the threshold value after the referral queue was established and, consequently, did not approve referrals already in the queue. Hence, high-risk referrals might have been auto-approved even though some low-risk referrals were waiting in the queue (Table II). Also, the credit control effectiveness of the original auto-approval strategy was unknown.

Factors affecting the authorization process

Basically, there are three major factors affecting the efficiency of the authorization process. They are:

(1) transaction volume;

(2) automatic authorization procedure; and

(3) the authorizers.

Transaction volume

Due to fluctuations in transaction volumes at different times of the day, the authorizers scheduled were not necessarily able to handle all the transactions. Consequently, long waiting queues would be built up at the point of sales. To deal with this, the authorizers tended to relax the normal credit inspection procedure in order to speed up the authorization process. Alternatively, service establishments would ask cardholders to use a different credit card, rather than to wait for an authorization decision. In the worst cases, service establishments would lose sales if the cardholders did not have other credit cards and were unwilling to wait for an authorization decision. Under these circumstances, not only do the cardholders suffer, but the service establishments would also tend to encourage the use of other credit cards. Thus, relations between the company and the service establishments would be damaged.

Automatic authorization procedure

The procedures involved in the authorization process could be classified as automatic and manual. A risk management system and an expert system would perform the automatic procedure, while authorizers performed the manual processes. However, the volume of referrals depended greatly on the discriminating ability of the automatic procedure, since ROCs would not be referred unless a decision could not be reached using the automatic procedure. As discriminating ability increased, the number of referrals decreased. While the efficiency of the procedures could significantly affect the cardholder's waiting time, the accuracy of the procedures could affect the effectiveness of credit control. Hence, the authorization procedures also played a major role in the quality of the authorization system.

Authorizers
A cardholder would be requested to have voice contact with an authorizer if both the expert system and the risk management system could not determine whether to deny or approve the ROC. The dialogue process between a cardholder and an authorizer was referred to as voice contact. The duration of the voice contact would depend on the training and experience of the authorizers, the attitude of the cardholder, and the amount of the request. An experienced authorizer would usually have already developed his own heuristics or methodology to detect fraudulent or bad transactions and, consequently, could significantly reduce the duration of voice contacts. Certainly, the duration could be reduced if a cardholder could immediately provide all the information requested by an authorizer. Each authorizer was empowered to approve requests within a certain limit, the amount of which was dependent on the performance and the seniority of the authorizer. If the amount requested was higher than the approved limit of an authorizer, the authorizer had to get approval from managers. Hence, the authorization process could be significantly delayed. The manual procedure performed by authorizers was the bottleneck of the overall authorization process as mentioned above (Figure 1).

Data collection and analysis

Transaction volume analysis
Since the volume of referral transactions was a major concern for the company, it had to analyse the arrival pattern of the referral transactions. First of all, the total number of transactions processed within a ten-minute period was collected and classified according to the day of the week. The compiled data showed that the arrival of referrals fluctuated with the time of day. It was also discovered that the referral volume was significantly lower during weekends. Nevertheless, three short periods were found to have a queue length greater than ten people due to a lack of authorizers (Figure 2).

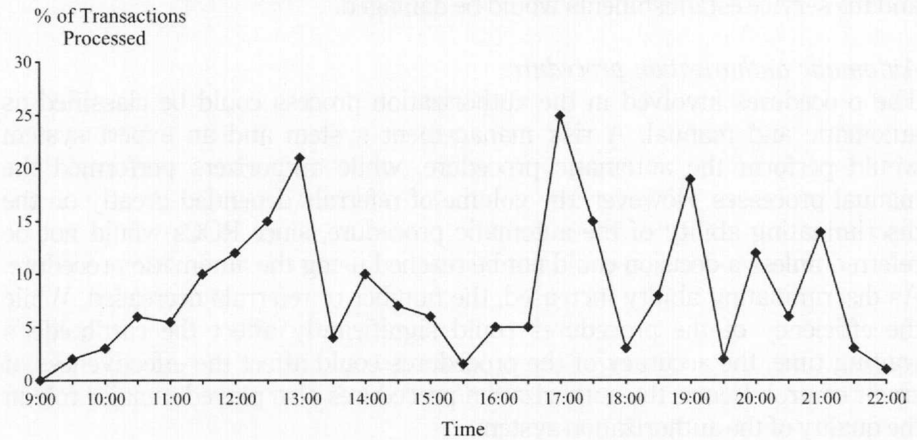

Figure 2.
The percentage of transactions processed lwhen the queue length is greater than ten people

Service quality analysis
After the arrival pattern of referrals was identified, the quality of the authorization process was then measured. One of the original measurements designed by the company to determine the quality of the authorization process was the percentage of referral transactions processed when the referral queue length was greater than ten people. Therefore, an analysis was carried out to determine the actual number of transactions processed that would fit the above criteria. The analysis showed that 3 per cent to 25 per cent of the transactions processed did not fit the criteria (Figure 2). However, it was found that there were only three problem periods: 12:30-13:00, 17:00-17:30 and 18:30-19:00. Since two problem periods occurred during the busiest period and one occurred during the normal period, the transaction volume could not fully explain the inefficiency of the authorization process. Therefore, an analysis of the scheduling of authorizers was performed.

Authorizer scheduling analysis
First, data on the arrival rate and the processing rate for authorization of referrals was collected. Then, the number of authorizers required to meet the desired service level was estimated using the M/G/1 queuing model and compared with the number of authorizers available at different periods of time (Table III). The desired service level was determined by reference to a customer survey. Details of the queuing model analysis will be discussed in the following section. The comparison showed that the number of authorizers available during the problem periods was about 13 per cent below the number required.

The new policy
Based on an analysis of the data in the previous section, two essential points for further improvement of service quality were identified. First, the company needed to handle transactions during peak hours and holidays more efficiently. Second, the company had to optimally utilize the authorizers available at different periods of time. However, the top management of the company also

Time	Authorizers available	Required authorizers	Over/understaffing
10:00	64	53	11
11:00	56	54	2
12:00	61	53	8
13:00	58	57	1
14:00	56	64	–8
15:00	43	43	0
16:00	38	41	–3
17:00	31	35	–4
18:00	27	32	–5

Table III. Analysis of available authorizers schedule believed that newly developed policies had to follow certain principles to guarantee a successful implementation. These principles were:

- be preventive rather than reactive;
- cope with the continuously changing business environment;
- minimize changes to the existing system; and
- maintain good relations with the service establishments.

Preventive vs reactive

To develop a preventive rather than reactive authorization process, a systematic sampling approach (Montgomery, 1996) was used to auto-approve ROCs. With this new process, referrals with less risk were selected for auto-approval even before a queue began. There were two major advantages to this approach. First, the referral volume could be reduced by auto-approving less risky ROCs instead of auto-approving relatively high-risk ROCs after a referral queue began to form. Second, it could save both telecommunications and referral costs.

To efficiently implement the above policy a simple method to evaluate the risk of each transaction in real time had to be found. Since fraudulent or bad transactions were always discovered among ROCs involving valuable resaleable items, the nature of items involved was a good indicator for evaluating the risk of a ROC. First, ROCs were classified into ten different categories (industries) according to the type of services requested by the cardholder. These categories include restaurants, hotels, gas stations and retail stores. A Pareto analysis was then performed to rank these ten categories according to their relative risks, which was measured as the probability of bad transactions, $P(b_i)$. The company limited the amount of charge for each category, so that the expected loss could be covered by the costs saved by the sampling inspection scheme.

That is:

$$L_i P(b_i) \leq S$$

where L_i = the limit of charge allowed for auto-approval for industry i; S = total savings; T_c = total telecommunications cost; $P(v)$ = probability of going through the voice contact procedure; V_c = total cost of voice contact; and S is calculated as $(T_c > +P(v)V_c)$.

For example, take P (bad transaction captured at the restaurant sector) = 1 per cent and S = \$0.25, then L(restaurant)= \$25. In other words, any transaction below \$25 initialized at a restaurant will not be inspected under normal conditions.

Since the current authorization policy has only been in implementation for a year, the cut-off value L_i for each industry i, is calculated on the basis of data from the last 12 months.

Coping with a continuously changing business environment

Since L_i is calculated from past data, the present business environment may not be accurately reflected. Therefore, to cope with a continuously changing business environment, three indicators based on the statistical process control approach could be used to detect fraudulent transactions or abnormal conditions:

(1) total denied transaction;

(2) total transactions; and

(3) total referred transactions.

For each service establishment, an average and a standard deviation of each indicator were calculated based on the previous month. If any of these indicators indicated an abnormality, then the auto-approval process would be terminated immediately until the causes of the phenomenon were identified. The algorithm for controlling abnormality could be summarized as follows:

tIf $|Xc_{ij} - Xa_{ij}| \leq 3\sigma_i$, (* i.e. the process is under control *)

then

switch on the auto-approval system.

Otherwise,

switch off the auto-approval system

check the cause(s) for abnormality

switch on the auto-approval system when the checking is done,

where Xc_{ij} stands for the current value of indicator *i* at service establishment j, Xa_{ij} stands for the average value of indicator i of the previous month at service establishment j, σ_{ij} stands for the standard deviation of indicator i at service establishment j, i = 1,2,3 (1 stands for total denied transactions, 2 stands for total transactions, 3 stands for total referred transactions, j = 1.. N, and N= total number of service establishments with auto-approval facilities installed.

So, the auto-approval decision became:

If ($R > L_i$) or (unusual condition(s) is/are detected)

then

perform usual authorization check.

Otherwise,

perform auto-approval,

where R = amount of dollars requested by a cardholder.

The overall design of the auto-approval system was shown in Figure 3. For example, take i = restaurant sector, and the average transaction per day of restaurant j in the previous month is 100, and the σ_{ij} = 10. If the total transactions today is 150, then $|Xc_{ij} - Xa_{ij}|$ = 50 which is bigger than $3\sigma_i$. Under this condition, the inspection process will be activated up to 100 per cent inspection.

The new policy offered at least two new advantages. First, an auto-approval decision could be made once a comparison between the amount of ROC and the cut-off value was completed. Therefore, the overall authorization process would not be delayed with the new policy. Second, the cut-off value would only be updated based on the total number of denied transactions at the end of the day. As a consequence, the cut-off value may be increased or decreased. Thus, the normal operations of service establishments would not be interfered with and the relations between the company, and the relationship with the service establishments could be well maintained. In fact, the new policy fulfilled all the requirements set by the top management of the company.

Service establishments with low transaction volume

One difficulty in installing an auto-approval system was establishing what the cut-off values (L_i) should be for service establishments that had just opened or service establishments with very low transaction volumes. Since these service establishments often provided insufficient data, it was very risky for the company to assume any cut-off value. To overcome this difficulty, the company had to set up a promotion strategy.

All new service establishments had an initial cut-off value of zero. The new cut-off value for the new establishment j was C_j>, which was equal to S/B$_j$, where BL_i was the probability of bad transactions. However, if the new cut-off value calculated was greater than the industry's cut-off value, then the cut-off value for service establishment j would be set to L_i for the first year. That is, $C_j = \min[\text{S/B}_j, L_i]$ for the first year. After the first year, if the calculated cut-off value was still greater than L_i, the upper limit would be relaxed and C_j would become S/B$_j$.

For service establishments with a very low volume of transactions, the industrial cut-off value would be used as the initial cut-off value. However, the upper limit would not be relaxed.

New scheduling policy

The second critical factor that affected the efficiency of the authorization process was the authorizers' schedule. Table III indicated that the authorization center was either over- or under-staffed for most of the time, if the target average time was less than ten seconds. As mentioned before, the average waiting time for cardholders depended on the number of authorizers available and the arrival pattern. The optimum number of authorizers could be estimated

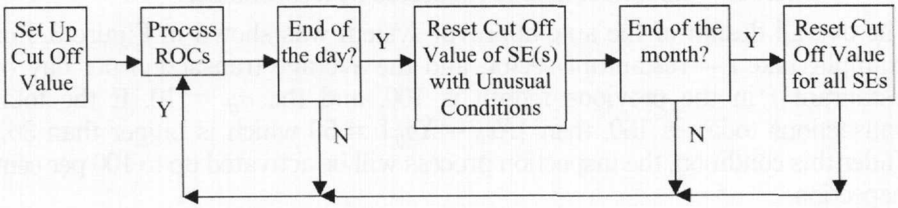

Figure 3.
Flowchart of new policy

based on queuing theories. Since the company was only concerned with the busiest periods which cause long referral queues, an analysis was carried out to identify the arrival pattern between 14:00-18:00. The analysis showed that the arrival pattern could be modeled by an exponential distribution. The processing times of ROCs by authorizers were identified as being normally distributed. To ensure that the data was collected under normal circumstances, the average processing times were estimated based on the data collected when the referral queue length was less than ten people. The distribution of the data was identified using Chi-Square test (Law and Kelton, 1991). The arrival pattern was identified to be exponentially distributed, while the processing time followed a normal distribution. Therefore, the authorization process for referrals could be modeled as a M/G/s queuing system, where s was the number of authorizers available. However, the computational effort to estimate the average waiting time with M/G/s increased drastically as s increased. Since we were more interested in the busiest times, the average waiting time was approximated by the following formula (Prahbu, 1997; Dshalalow, 1997):

$$W_q = L_q/\lambda,$$

where $L_q = (\lambda^2\sigma^2 + \rho^2) / 2(1\text{-}\rho)$, λ = arrival rate of referrals, $\rho = \lambda/\mu, \sigma$ = standard deviation of the referral processing time, $\mu = s\mu_a$, and μ_2 = an authorizer's processing rate of ROCs.

The new algorithms for controlling the referral transactions are summarized below:

(1) *Set up parameters*:

- desirable average waiting time (W_d) = 10 secs;
- sampling time interval to detect arrival rate = 30 secs;
- average processing time of a referral = 120 secs; and
- variance of the processing time (V)= 10 secs.

(2) *Estimate the arrival rate using the real-time data*:

Take

the estimated arrival rate (λ_e) = 1/5 = 0.2

the number of authorizers on duty = 10

then

the maximum processing rate (μ)= 10 * 1/60 = 0.17

Get the desired arrival rate (λ_a) such that the average waiting time can be adjusted below the desired average waiting time (W_d) , then

$$(\lambda_a) = 2(W_d)(V^2)/(1+\text{\textbackslash mu}^2 V + 2W_d V) = 0.12$$

the rate of auto-approval for the referral transactions = (λ_a)– (λ_e) = 0.08.

Special transactions handling

Although the theoretical optimal number of authorizers could be estimated with a M/G/s model, the number of authorizers scheduled at each period was constrained by the company's manpower allocation policy. To attract more qualified persons to work as authorizers, the company schedules at least four hours per shift for each authorizer. As a result, authorizers might be called in one or two hours before the busiest periods started, to fulfill the shift requirement mentioned. Therefore, authorizers might have a fairly high percentage of idle time during the slow periods. To reduce the cost of improving the quality of the authorization process, the company has designed a flexible transaction handling system. This system scheduled authorizers to handle special transactions that did not require voice contact. These kinds of ROCs were received from service establishments without direct computer links with the company. Under this flexible scheduling policy, an optimal number of authorizers was allocated to handle regular ROCs. Whenever the estimated waiting time calculated by the M/G/s model was greater than the target waiting time, authorizers responsible for handling special transactions would be reallocated to handle regular transactions. Hence, there were always enough authorizers to handle regular ROCs and over-staffing would not occur.

Policy analysis

An analysis based on 12 months of implementation was carried out, to evaluate the effectiveness of the new authorizer allocation policy. Using the new algorithm and measurement method, the results showed that the average waiting time was below 50 seconds for 99 per cent of the time. As a result, US$1.4 million was saved annually, due to the authorizers tending not to relax credit control during the busiest periods. The saving was calculated as $(T_{old} - T_{new})^* P_{bad}$ where T_{old} is the amount of credit auto-approved by the old system due to the long waiting time, T_{new} is the amount of credit auto-approved by the new system due to the long waiting time, P_{bad} is the the probability of discovering fraudulent transactions after checking by authorizers.

Conclusion and summary

This paper has demonstrated how quantitative tools can be used to improve the efficiency and quality of a process. Also, it shows that an appropriate quality performance indicator does not only give an accurate assessment, but can also save a great deal of money for a company. Quality control techniques, which have been successfully used in mass production, can also be applied to service industries. Using this new inspection scheme, which replaces the original 100 per cent inspection scheme, the overall operation cost can be significantly reduced. Quantitative methods such as the queuing theory can play an important role in implementing business process redesign. More than US$2 million can be saved by a single company annually by applying a queuing model to assist in the scheduling of authorizers (Table IV). The average waiting time is reduced from 50 seconds to 30 seconds during the busiest periods. The sum of US$0.3 million can be saved by applying a sampling inspection scheme rather than a 100 per cent inspection scheme.

	Savings (US$)
Credit losses saved by the auto-approval strategy	0.8 million
Credit losses saved by the new authorizers schedule	1.4 million
Cost saved by applying inspection sampling scheme	0.3 million

Notes: Credit losses saved by the auto-approval strategy = (total amount auto-approved by the new system – total amount of auto-approved by the old system) * (probability of getting a bad transaction). Cost saved by applying inspection sampling scheme = (total referral transactions that are not inspected* referral cost – total loss due to non-checked bad transactions). Credit losses saved by the new authorizer schedule = (credit losses due to the relaxation of the credit control by the authorizers when the old scheduling approach was used)

Table IV. Total savings of the new policy

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