Application of Computer Simulation for Optimizing Branchless Banking Opportunities via Cell Phones

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***Abstract*— Mobile Financial Services (MFS) are new phenomena in the world of Mobile Commerce (m-Commerce) which helps customers to interact with a bank via mobile device and makes banking virtually anywhere on a real-time basis a reality. This study investigates the impact of adopting MFS applications on minimizing service channels costs for Palestine Islamic Bank (PIB) in Khan Younis. Two types of models to analyse and evaluate the impact of adopting banking servicing opportunities via cell phones are presented. The first is a computer simulation model used for shedding some light on how inputs may affect the responses of interest. The second depends on the outputs of simulation experiment for finding the optimum combinations of input parameters by following Response Surface Methodology (RSM) assuming certain level of customers representing the early adopters will use MFS.**

***Keywords*— Arena Simulation, Computer Modelling, Optimization, Response Surface Methodology, Mobile Commerce, Mobile Financial Services, Operation Research.**

1. Introduction

Service industry has been developing rapidly and receiving more attention in the recent years by system modelers. Customer satisfaction is a growing concern in service industry settings such as banks, hospitals, and call centers. High variability in demand is prevalent in the service industry, and customers still expect to be served promptly when they arrive [1]. Therefore, there is a need for efficient staff utilization with minimal possible cost, taking into account varying demand levels for the day of the week, or even for the time of the day.

Improving customer satisfaction and service levels usually requires extra investments. To decide whether or not to invest, it is important to know the effect of the investment on the waiting time, and service cost. Usually managers and decision makers seek to balance between the service and waiting time cost to offer the best service with minimal cost [2]. Figure (1) shows the relation between these costs and how to obtain the minimum aggregate cost and optimal capacity.

Branch offices historically have been one of a bank's major costs as well as its main contact points with retail customers. This makes branches a logical target for efforts to cut costs and increase productivity. The movement to increase productivity and cut costs in branches led to the development of new channels for servicing opportunities, these opportunities offered the potential for reducing average transaction costs and less need for brick-and-mortar branch offices and tellers [3].

Mobile Financial Services (MFS) are a new phenomenon in the world of m-Commerce which helps customers to interact with a bank via a mobile device and makes banking virtually anywhere on a real-time basis a reality.

This study investigates the impact of adopting MFS applications on minimizing service channels costs and improving the performance of servicing levels for Palestine Islamic Bank (PIB) in Khan Younis.

Two types of models to analyze and evaluate the impact of adopting banking servicing opportunities via cell phones are presented. The first is a computer simulation model used for shedding some light on how inputs may affect the responses of interest. The second depends on the outputs of simulation experiment for finding the optimum combinations of input parameters by following Response Surface Methodology (RSM) assuming certain level of customers representing the early adopters will use MFS.

Arena Simulation Package is used to simulate the current banking system as to analyse the current performance and possible changes that could be made. By accurately simulating a process or system, the decision maker can see the outcomes of changes without implementing them in real-time, thus saving valuable time and resources. Design Experts 7.1 statistical package is used for constructing RSM plots and optimizing the input parameters for Tellers service channel.

2. System Description and Data Collection

PIB in Khan Younis is a small branch office of a national scale bank in Palestine. Services provided by this branch office include: savings, account deposits and withdrawals, transfer of funds, foreign currency exchange, and ATM services. The process of interest within this branch office is the service delivered to customers via tellers and ATM channels.

There are five counters in the tellers' area which can physically be opened as shown in Figure (2), but current practice at the bank is to open two counters permanently -Permanent Tellers (PT)- with the additional counters being opened only during rush days and peak hours as needed. The additional counters served by Temporary Tellers (TT) called from the administrative employees.

The data collection stage gathers observations about system characteristics over time. The data used for the simulation model were collected during January, February, and March 2008. It consists of the total number of daily customer arrivals for the tellers and ATM service distribution channels during months of January and February 2008, the rates of customers arrival during day hours to the bank, average rates of service time for tellers and ATM resources, average waiting time for customers, average queuing lines length, cost for operating one teller and one ATM resource, average transaction cost for the transactions executed via tellers and ATM service channels. The data were collected from historical records, statistics, and supported with daily observations from the field.

3. Computer Simulation

The main goal of the simulation study is to examine new opportunities for distributing banking services via MFS. It will explore and evaluate the impact of MFS on improving customer satisfaction and reducing service costs for service channels.

The following assumptions were adopted for the purpose of modelling the system under investigation:

- Bank opens at 8:30AM and offers services for customers through tellers group until 1:00PM. At 1:00PM the bank closes but the customers in the bank at that time will be served. Customers come to the tellers' area with escorts.
- ATM services available for customers' usage between 8:00AM and 8:00PM only.
- Each teller serves customers from the same queue only and all tellers work at the same speed.
- During normal days, only two permanent tellers are working with the possibility to activate a temporary teller come from the back office if number of customers exceeds 30 customers. During rush days, two temporary tellers will be working in addition to the two permanent tellers but if the number of customers exceeds 50 customer in the lobby, a third temporary teller will be activated.
- Tellers do not have lunch hours, but do leave the counter from time-to-time. However, a teller will finish serving the current customers in the queue before leaving the counter.
- By default, all tellers can handle all types of customer transactions. There are no special service queues, but it might happen from time-to-time to let any teller serves a specific type of customers during day hours.
- There is no queue capacity limitation. This means that the building is large enough for the assumption of an infinite capacity is reasonable.
- When faced with several queues, customers tend to pick the shortest. However, all tellers will have an equal opportunity to serve any customer. All queues follow a First-In First-Out (FIFO) priority.
- Reneging and jockeying are neglected. However, a small percentage of customers may balk during normal and rush days.
- ATM machine may fail during period of operation due to power supply failure. If the failure was during branch office working hours, ATM customer will enter the bank and join tellers' area queues to be served; otherwise he/she may leave without being served.

Customers' arrival statistics shows that number of arrivals fluctuate throughout the rush day hours as shown in Table 1.

TABLE 1
OBSERVED AVERAGE ARRIVALS DURING RUSH DAYS

Time Period	Observed Average Arrivals During Rush Days	
	Tellers Service Channel	**ATM Service Channel**
08:00-09:00	114	26
09:00-10:00	254	31
10:00-11:00	287	49
11:00-12:00	388	52
12:00-13:00	293	54
13:00-14:00	-	35
14:00-15:00	-	15
15:00-16:00	-	13
16:00-17:00	-	12
17:00-18:00	-	14
18:00-19:00	-	12
19:00-20:00	-	11

4. Experimentation and Results

The study consisted of two major phases. The first phase handled problem formulation and objectives of the overall project plan including collecting the data for the simulation experiment, simulation model conceptualization and translation, in addition to verification and validation. The second phase handled experimental design and run for the simulation experiment. The outputs of the simulation experiment at this phase were used to RSM plots for the responses of interest. RSM used as an optimization technique for the main inputs of interest.

4.1 Experimental Design

A discrete event simulation model was created using Arena Simulation Package version 7. The model follows individual customers as they move through the bank teller/ATM systems. Flow of a customer would be as follows: Customer A arrives at the bank according to the arrival rate at a particular time of day. He enters the building and joins the shortest waiting line queue for service (It was assumed that 5% of the total customers may balk during rush days). Each time a teller becomes available, when they have finished serving a customer, the teller will call the next customer in line to approach the counter for service. When Customer A is called to a counter, he approaches and is serviced by the teller. Once service has ended, Customer A leaves the bank. The teller who serviced Customer A calls the next waiting customer to the counter. Number of operating tellers was changing during day hours. By default, four tellers will be working until the number of waiting customers in the lobby exceeds 50 customers, which is the point at which a fifth teller will start working until customers become below 30.

An essential step when designing any simulation model is to simulate the process over a specified period of time. It is important to tell Arena how long to run the simulation model and how many replications we need.

Most simulations can be classified as either terminating or steady-state (long run) [4]. A terminating simulation – in contrary to steady-state – for a single run will terminate according to some model specified rule or condition, which is the same as the case being analyzed in this study. The bank opens at 8:30AM with no customers present meanwhile ATM machine starts operating at 8:00AM. The bank closes its doors at 1:00PM, and then continues its operation until all customers are flushed out. The ATM machine continues its operation until 8:00 PM as it was not possible to collect data after this time limit; therefore the single simulation run was selected to start from 7:00AM to 9:00PM (840 minutes) with a one hour time margin at the beginning and at the end of each work day for the purpose of monitoring and validating customers' behaviour during the simulation run.

Each simulation run is replicated for 100 times, simulating a 100 day of operation for each combination of design points shown in table (2) that will be discussed in section 4.2. The service processing rate is assumed to be homogeneous for all the tellers. Banking administrations usually circulate employees as to enhance their skills and improve performance levels; therefore it is assumed that all staff members have similar skills and performance levels. The service process is modelled using the triangular distribution as its parameters are fairly easy to understand [4]. Figure (3) illustrates minimum, most likely, and maximum service times for Tellers and ATM service channels during rush days.

4.2 Building RSM Plots

The use of Response Surface Methodology and Meta-Model procedure was involving the following steps: (1) Using 2^k Factorial designs for screening, (2) Using Central Composite Design (CCD) for building second order regression models, and (3) Optimizing model parameters during early adopters' stage.

The 2^k Factorial experiment design was developed with the physical experiments in mind (like industrial applications) and can easily be used in computer simulation experiments as well [5]. It is useful for shedding some light on which input parameters (factors) are most important and how they affect the responses of the experiment. The 2^k Factorial experiment design technique is based on identifying two values, or levels, of each of model input factors. There is no general prescription on how to set these levels, but it is important to set them to be "opposite" in nature but not so extreme that they are unrealistic [5].

If we have k input factors, then will have 2^k different combinations of the input factors, each defining a different opportunity of the model. Referring to the two levels of each factor as the "–1" and "+1" level, this can form what is called a design matrix describing exactly what each of the 2k different model opportunities are in terms of their input factor levels. Each row represents a particular combination of factor levels, and is called a design point.

For this study, set of opportunities were developed for modifying Permanent and Temporary Tellers (PT & TT) (factors A and B respectively) staffing levels under two distinct levels of MFS usage (factor C) as to examine the impact of different combinations on the responses of the model (like average total cost, average waiting time … etc.), thus we have three input controls (k = 3 factors), and 2^3= 8 runs representing cubic points for the full factorial experiment as shown in Fig. (4).

Permanent and Temporary Tellers staffing levels were considered to be *controlled* input parameters (factors) for the simulation experiment as we can control the values of these factors meanwhile MFS usage factor was found to be *uncontrolled* as we do not have clear image on the percentage of usage at any specific point of time.

Central Composite Design (CCD) is a two level (2^k) factorial design, augmented by n_0 *Center Points*, and two *Star (Axial) Points* positioned at ($\pm\alpha$) for each factor as shown in Figure (5) for a three factors experiment design. Setting (α = 1) locates the star points on the centers of the *faces* of the cube, giving a Face centered Central Composite (CCF) design.

CCD is useful in RSM for building a *second order* (quadratic) regression model for the response variable without needing to use a complete *three* level (3^k) factorial experiment for evaluating main and quadratic effects and interactions.

Table (2) shows the design matrix after using CCD for both normal and rush days configurations. Arena Process Analyzer was used to run the simulation experiment for these design points and record the responses for: (1) Tellers channel cost and wait time, and (2) ATM channel cost and wait time as a result for using MFS.

The outputs of Arena Process Analyzer were then processed by Design Experts (DX) software [6] in order to perform statistical analysis based on CCD experiment design as to construct response surface plots in addition to regression models for the responses that might be used later by decision makers to predict the outputs of simulation experiment. The use of meta-models can help to find the combination of input factor values that *optimizes* (i.e., minimizes or maximizes, as appropriate under some constraints) responses which is the task that will be handled in the next step.

4.3 The Results

The responses of the basic simulation model were compared to the MFS-based simulation model responses. The results shown in table (3) indicates that the 36.5% of MFS early adopters will reduce customers waiting time in the tellers area to (10.82 minutes) on average with a total cost of (487.30 $/Day), which is much less than the total cost of tellers area without using MFS (1735.47 $/Day). In addition, ATM service delivery channel cost might reach (76.08 \$/Day) with an average service time of (3.52 minutes) which is again much less than current basic configuration. At this level of MFS usage, there is a possibility to generate (38.01 \$/Day) net profit from the current customers base during rush days.

TABLE 2
OBSERVED AVERAGE ARRIVALS DURING RUSH DAYS

Design Point	Design Point Type	Factor 1: Number of Permanent Tellers		Factor 2: Number of Temporary Tellers		Factor 3: Percent of Usage for MFS	
		Coded	Natural	Coded	Natural	Coded	Natural
1	**Factorial**	**-1**	**3**	**-1**	**0**	**-1**	**20**
2	**Factorial**	**+1**	**5**	**-1**	**0**	**-1**	**20**
3	**Factorial**	**-1**	**3**	**+1**	**2**	**-1**	**20**
4	**Factorial**	**+1**	**5**	**+1**	**2**	**-1**	**20**
5	**Factorial**	**-1**	**3**	**-1**	**0**	**+1**	**60**
6	**Factorial**	**+1**	**5**	**-1**	**0**	**+1**	**60**
7	**Factorial**	**-1**	**3**	**+1**	**2**	**+1**	**60**
8	**Factorial**	**+1**	**5**	**+1**	**2**	**+1**	**60**
9	**Center**	**0**	**4**	**0**	**1**	**0**	**40**
10	**Axial**	$-\alpha^{(*)}$	**3**	**0**	**1**	**0**	**40**
11	**Axial**	$+\alpha^{(*)}$	**5**	**0**	**1**	**0**	**40**
12	**Axial**	**0**	**4**	$-\alpha^{(*)}$	**0**	**0**	**40**
13	**Axial**	**0**	**4**	$+\alpha^{(*)}$	**2**	**0**	**40**
14	**Axial**	**0**	**4**	**0**	**1**	$-\alpha^{(*)}$	**20**
15	**Axial**	**0**	**4**	**0**	**1**	$+\alpha^{(*)}$	**60**

$(*)\ \alpha = 1$

TABLE 3
COMPARING BASIC AND MFS_BASED FOR RUSH DAYS

Simulation Model	PT (No.)	TT (No.)	MFS Usage (%)	Teller Area Total Cost (\$/Day)	Teller Customer Wait Time (Minutes)	ATM Area Total Cost (\$/Day)	ATM Customer Wait Time (Minutes)
Basic	4	1	0%	1735.47	43.03	486.52	26.33
MFS	4	1	36.5%	487.30	10.82	76.03	3.52

DX software was used for locating the sweet spot area with multiple responses that satisfies the constraints listed in table (4) and help to find the combination of input factor values that optimizes responses in order to achieve the required goals.

TABLE 4
CONSTRAINTS AND GOALS TO BE ACHIEVED FOR A RUSH DAY

Name	Goal	Lower Limit	Upper Limit
PT (Number)	is in range	3	5
TT (Number)	is in range	0	2
MFS (%)	is equal to 36.50	20	60
Teller Area Total Cost (\$/Day)	minimize	214.26	2562.28
Customer Wait Time – Tellers Area (Minutes)	is target = 10	10	15
ATM Area Total Cost (\$/Day)	minimize	17.78	249.24
Customer Wait Time – ATM Area (Minutes)	is in range	0.29	13.23
Net Profit (\$/Day)	Maximize	20.59	62.42

The output of DX shows that the stationary point of the fitted response surfaces X_o = (PT, TT, MFS) = (3.99, 0, 36.5) which yields predicted mean responses of Y_o = (Y1, Y2, Y3, Y4, Y5) = (449.43, 9.99, 65.04, 3.17, 37.10) a maximum in the experimental region as shown in table (5) with a solution desirability of 86.865%.

TABLE 5
THE DX OPTIMIZATION PROCESS OUTPUT FOR A RUSH DAY CONSRAINTS AND GOALS

Solution Number	X1: PT (No.)	X2: TT (No.)	X3: MFS (%)	Y1: Tellers Area Total Cost (\$/Day)	Y2: Tellers Area Customer Wait time (Minutes)	Y3: ATM Area Total Cost (\$/Day)	Y4: ATM Area Customer Wait Time (Minutes)	Solution Desirability (%)
1	***3.99***	***0***	***36.5***	***449.43***	***9.99***	***65.04***	***3.17***	***86.865***
2	3.99	0	36.5	450.62	9.99	65.04	3.17	86.861
3	3.99	0.12	36.5	452.21	10.00	65.04	3.17	86.857
4	3.99	0.13	36.5	452.41	9.99	65.04	3.17	86.851
5	3.99	0.25	36.5	455.03	10.00	65.04	3.17	86.843
6	3.99	0.57	36.5	462.41	10.00	65.04	3.17	86.814
7	3.99	1.55	36.5	484.96	9.99	65.04	3.17	86.725
8	3.99	1.74	36.5	489.48	10.00	65.04	3.17	86.701
9	3.99	1.82	36.5	491.34	9.99	65.04	3.17	86.690

If we take the combination of nearest integer values of PT and TT as X = (PT, TT, MFS) = (4, 0, 36.5), the output responses will be Y = (Y1, Y2, Y3, Y4, Y5) = (447.70, 9.93, 65.04, 3.17, 37.10) which is very close to Y_o as X is very close to X_o and lays within the solution desirability region as shown in Fig. (6) which leads us to conclude that X is the optimal solution for a rush day configuration.

Figures (7), (8), (9), and (10), shows the response surface plots of the tellers area total cost and customers waiting time, ATM area total cost and customers waiting time responses respectively at the level of 36.5% of customers are using MFS. These plots confirms the results of DX optimization output for the optimal solution as the lowest cost of tellers area seems to be achieved at 4 permanent tellers only with a waiting time between 5 and 15 minutes.

Figures (9), and (10)) explain that ATM channel total cost, and ATM channel customers waiting time responses is constant at all points since these responses are a function of MFS usage factor only.

5. Conclusion

Banking will no longer be constrained to conventional service channels. Mobile Financial Services (MFS) are new phenomena in the world of M-Commerce which helps customers to interact with a bank via a mobile device and makes banking virtually anywhere on a real-time basis a reality. MFS can be divided into two sub-categories: Mobile Payment (M-Payment) and Mobile Banking (M-Banking). The advantage for the customers lies in the fact that they does not need to carry cash. Therefore, MFS can be seen as a promising M-Commerce application.

If implemented proficiently, MFS can help financial institutions and banks in Palestine to improve customer acquisition and customer retention, reduce total service costs for costly branch offices by migrating simple transactions away from these branches.

This study has shown how MFS may affect PIB operations in Khan Younis branch during normal and rush days. The simulation has been valuable in providing a flexible environment in which to model PIB for Khan Younis branch and gather information about the arrival patterns and key performance indicators which were necessary for running the simulation experiment and applying RSM as an optimization technique. The RSM is used to find the optimum levels of the considered factors to ensure a well-designed physical system.

By simulating the behaviour of the queuing systems in the bank for both types of days at the level of 36.5% of customers are willing to use MFS, the study concluded that:

- During Rush Days: It has be shown that providing 4 permanent tellers with a solution desirability of 86.86% will lead to the required minimum average of customers waiting time (9.93 Minutes) as to serve customers within 10 to 15 minutes at a total average cost for tellers service channel of (447.70 $/Day), which is much less than the total average cost for tellers area without using MFS (1735.47 $/Day), in addition for eliminating the need for a temporary tellers during day hours to be ready. At this level of MFS usage, the total average cost and waiting time for ATM service channel will be reduced to (65.04 $/Day) and (3.17 Minutes) respectively which is again much less than the average cost and wait time for ATM area without using MFS. In addition, this level of MFS usage will allow for an opportunity of a maximum of (37.10 $/Day) net profit that might be generated from the current customers base.

Good utilization of MFS will help to find new methods for payments and money withdrawals as to overcome the difficulties appeared in Gaza Strip area resulting from the limitations for supplying Israeli Shekels, US Dollars and Jordanian Dinars to the Palestinian banks which were used for day-to-day transactions and caused many difficulties for both customers and banks. It is important for Palestinian banks to learn from successful stories were applied around the world.

In conclusion, MFS is offering several benefits and added value to banks and customers alike. Mobile operators value M-Commerce applications much. Moreover customers' perception of MFS as a new innovation will affect the rate of adoption. Many innovations require a lengthy period of many years from the time when they become available to the time when they are widely adopted. Therefore, a common problem for many banks is how to speed up the rate of diffusion of MFS. The challenge for banking sector in Palestine is not to get unbanked to the bank, but to get the bank to the unbanked.

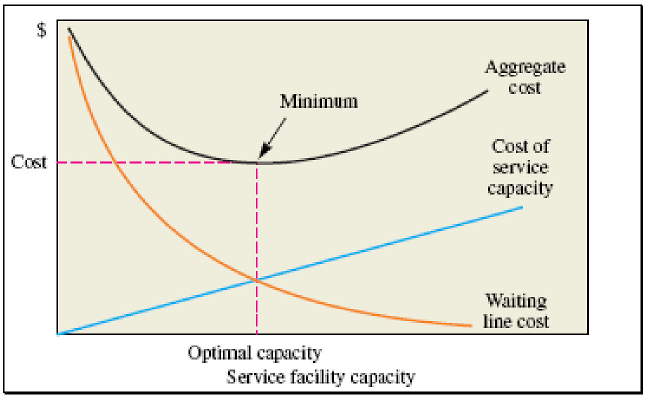

Fig. 1 Waiting line versus service capacity level trade-off
Source: (Chase, 2007)

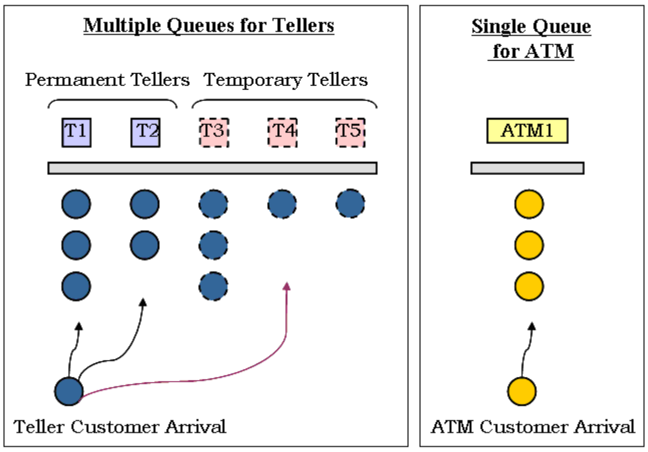

Fig. 2 Tellers and ATM services subsystems

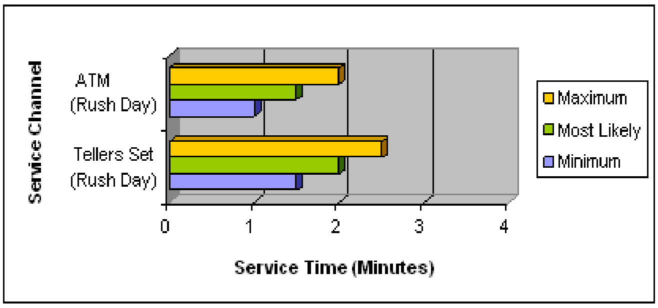

Fig. 3 Service rates for service channels

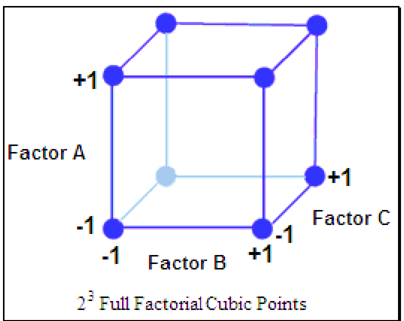

Fig. 4 Cubic points of 2^3 full factorial design
Source: Modified from (Sanchez, 2007)

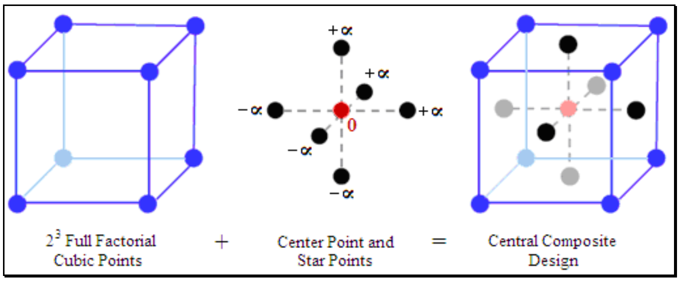

Fig 5 Construction of Central Composite Design (CCD)
Source: Modified from (Sanchez, 2007)

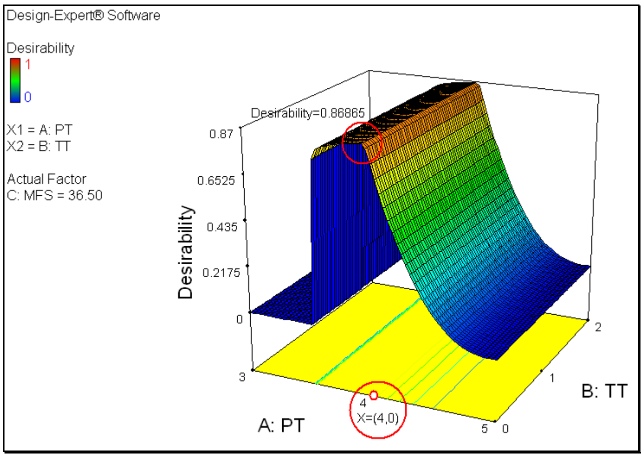

Fig 6 Desirability plot of rush day solutions

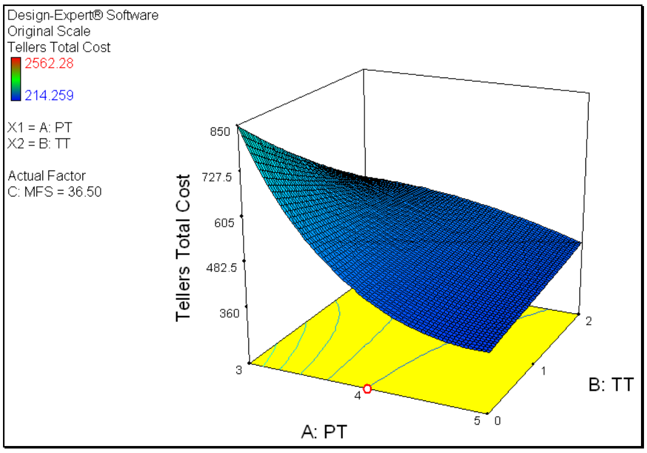

Fig. 7 Total cost response of tellers channel during rush day

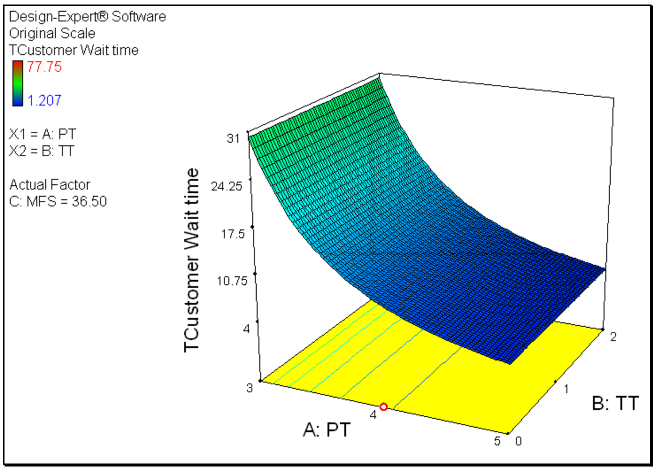

Fig. 8 Customers waiting time response of tellers channel during rush day

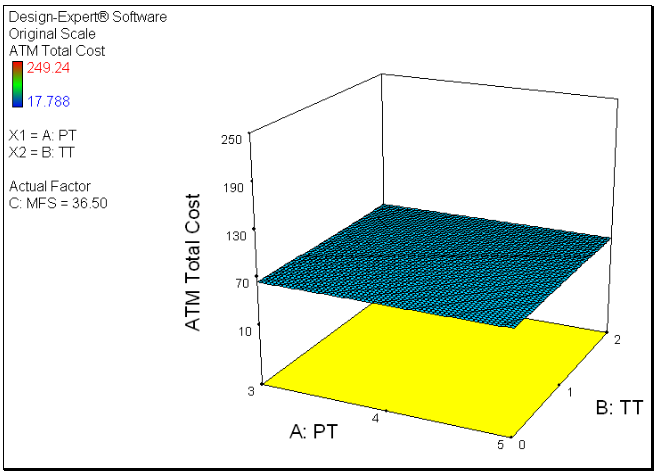

Fig. 9 Total cost response of ATM channel during rush day

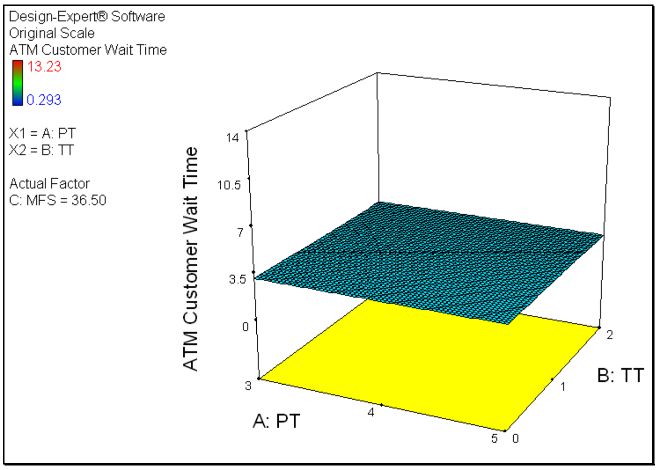

Fig 10 Customers waiting time response of ATM channel during rush day

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