BUSINESS PROCESS IMPROVEMENT USING ADJUSTABLE PARAMETERS ON SIMULATION: A CASE STUDY IN RESTAURANT BUSINESS

Miss Salinthip Somphanpae

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By	Miss Salinthip Somphanpae
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Thesis Advisor	Assistant Professor Somjai Boonsiri, Ph.D.

Accepted by the Faculty of Science, Chulalongkorn University in Partial Fulfillment of the Requirements for the Master's Degree

....Dean of the Faculty of Science

(Associate Professor Polkit Sangvanich, Ph.D.)

THESIS COMMITTEE

....Chairman

(Associate Professor Peraphon Sophatsathit, Ph.D.)

....Thesis Advisor

(Assistant Professor Somjai Boonsiri, Ph.D.)

....External Examiner

(Assistant Professor Waralak Vongdoiwang Siricharoen, Ph.D.)

สลิลทิพย์ สมพันธ์แพ : การพัฒนากระบวนการทางธุรกิจด้วยวิธีปรับตัวแปรโดยการจำลองสถานการณ์: กรณีศึกษาธุรกิจภัตตาคาร (BUSINESS PROCESS IMPROVEMENT USING ADJUSTABLE PARAMETERS ON SIMULATION: A CASE STUDY IN RESTAURANT BUSINESS) อ.ที่ปรึกษาวิทยานิพนธ์หลัก: ผศ. ดร.สมใจ บุญศิริ, 50 หน้า.

กระบวนการทางธุรกิจมีบทบาทสำคัญในทุกองค์กร มันจะเป็นตัวสร้างกำไรหรือทำให้ขาดทุนขึ้นอยู่กับการจัดการกระบวนการขั้นตอนที่มีประสิทธิภาพ ดังนั้นการรับมือกับการเปลี่ยนแปลงภายในและภายนอกองค์กรนั้นจึงจำเป็นต้องพัฒนาและเพิ่มประสิทธิภาพให้กับกระบวนการเพื่อการอยู่รอดและได้เปรียบในการแข่งขันในตลาดธุรกิจ แนวคิดการพัฒนากระบวนทางธุรกิจจึงเป็นอีกหนึ่งหนทางของการพัฒนากระบวนการที่มีอยู่โดยใช้วิธีออกแบบกระบวนการใหม่ ในงานวิจัยนี้จะนำการประยุกต์ของแนวคิดของการพัฒนากระบวนการกับวิธีการออกแบบกระบวนการใหม่รวมเข้ากับการจำลองกระบวนการเพื่อหาปัจจัยที่มีอิทธิพลต่อกระบวนการ นั่นก็คือจำนวนของตัวแปรที่เหมาะสมที่จะช่วยพัฒนาประสิทธิภาพของกระบวนการซึ่งจะถูกพิจารณาว่าตัวแปรใดเป็นตัวที่ทำให้เกิดเวลาตอบสนองบริการที่ช้าและมีผลกระทบต่อเวลาของการรอคิว, รอบเวลาการทำงานของกระบวนการ และ ต้นทุนของการดำเนินการ ซึ่งจะถูกแสดงออกมาเป็นผลลัพธ์ของการจำลองกระบวนการ ส่วนการตรวจสอบว่าจะสามารถนำผลลัพธ์จากการจำลองมาใช้กับเหตุการณ์จริงได้หรือไม่จะทำการเปรียบเทียบระหว่างผลลัพธ์การจำลองกับข้อมูลที่ได้สังเกตจากเหตุการณ์จริง

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The business process plays an important role in every organization. It can make a profit or loss depending on effective management procedures. Thus, in response to change inside and outside the organization, they need to improve and optimize their processes for survival and competitive advantage in the market. Business Process Improvement (BPI) is a way of improving the existing process by using process redesign heuristics. In this work, BPI methodology is adapted. An integrated simulation is performed to measure the influencing factors to the BPI. An effective number of parameters for improving the process performance characteristics are proposed by considering those which affect the slow service response time and impact on queue time, cycle time, number of task completed, and cost of operating the process. Simulation results are shown and compared with the observation data to validate, if those characteristics are valid in real situation.

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CHAPTER 1

INTRODUCTION

In this chapter, the introduction of business process and business process improvement is introduced. Problem statements, expected results, scope and contribution of this work are stated. The main research questions and what is going to investigate in this work will also be explained.

1.1 Introduction

The business process plays a very important role in all organizations, including restaurants, retail stores and hospitals. In order to achieve the objectives of an organization, they need to build a competitive advantage in the market and, improve its the business process. Each business also needs to continually improve to quickly respond to market change and sustain its competitiveness. Business process improvement (BPI) is one method to help a business improve and deploy process redesign heuristics. Dumas, M. et al. [1] defined process redesign as improving the quality of products and services by rethinking and reorganizing the business process to increase the performance. With respect to the customer waiting time, the service process design was used to evaluate the effect of the arrangement of facilities and the provision of processes through which the operations were structured and delivered [2].

The time spent waiting by customers is very critical in today's business environment [3], and organizations must change in order to service customers in the shortest possible time while still maintaining the same or improved (above previous minimal acceptable) standards of service. Therefore, organizations must consider how to improve their respective processes to be efficient and effective. One way to analyze the process quality is to simulate and assess its dynamic behavior over time. By using simulations, organizations can predict how the business processes perform under specific conditions. Process simulation can identify the most effective flow and help prevent problems arising during execution. Indeed, the simulation approach can be used to model the business process, provide resources and cost estimations of the proposed model, and analyze any financial constraints [4]. The results may assist in decision-making, process design, or resource provision with the goal of improving factors, such as process performance, product quality, and resource utilization. To ensure efficiency, simulation tool is used to test the performance by adjusting the parameters and comparing between the current and the new processes [5]. The results of the simulation represent the most effective number of resources to improve the performance characteristics of the service process. The performance characteristics are measured in terms of cost of cycle time, queue time, tasks completed, and cost of operating the process.

1.2 Problem statements

This research studied the service process in the restaurant business with the aim to improve the current process. Wasted activities were eliminated and the residual activities were defined as the new processes. The problem of how this would be carried out depending on the effective number of parameters that provided the highest performance characteristics of the service process as follows: (i) cost of operating the process, (ii) the customer queue time, (iii) the cycle time and (iv) the number of tasks completed in the fixed period.

1.3 Expected results

1. Obtain the effective number of resources (in this case each type of staff) that optimally improves performance characteristics of the service process.

2. Validate the proposed methodology in improving the organization performance from the simulation of the service process in a case study of an actual restaurant business.

1.4 Scope of this work

This research was limited in its scope by (i) focusing on the service process in the restaurant business, (ii) using the simulation tool BPsimulator [5], and (iii) restricting the adjustable parameters to the number of resources related to the service process.

1.5 Contribution of this work

Obtain the effective number of resources for the current and the new process of the restaurant business that optimize the performance of service.

Document organization

This document is organized as follows. Relevant literature reviews and related theories are presented in Chapter 2, followed by the proposed methodology in Chapter 3. The case study and the experimental results are presented and discussed in Chapter 4, while the conclusion and future work are given in Chapter 5.

CHAPTER 2

LITERATURE REVIEW AND RELATED THEORIES

In this chapter, the relevant literature and related theories to this research are reviewed. Specifically, the service quality, relationship between the waiting service and customer satisfaction, restaurant business process, BPI methodology, process redesign, and the measures used for process performance characteristics are reviewed. The related theories reviewed include the business process model, elements of a business process, BPI and the BPsimulator-based simulation.

2.1 Literature review

2.1.1 Service quality

The service quality will affect the customer's emotional satisfaction and this in turn may have a positive effect on both customer loyalty and customer-business relationship quality [6]. Tsoukatos, E. and Rand, G.K. [7] found the difference between emotional loyalty and behavioral loyalty as an additional support for the links between service quality, customer satisfaction and loyalty, where emotional loyalty was said to mediate the effect of satisfaction on behavioral loyalty. The importance of the service quality on customer loyalty was shown, where service quality was found to affect the intention of customers to stay in a relationship with the service provider [8]. Several researchers have measured the relationships among service quality, customer satisfaction and behavioral intentions [9-11]. In addition, a survey of restaurant customers revealed that the highest ranked complaint about the restaurant service was a slow service (response time) [12], being the most common complaint in 66.3 and 60.8% of respondents in India and U.S.A., respectively, (Table 1). One reason for a slow service is of course an inefficient service process.

Table 1. Survey results of customers' complaints[a]

Specific complaint	India		USA	
	%	Rank	%	Rank
1. Operations:				
- Slow service	66.3	1	60.8	1
- Inefficient staff	17.9	4	21.6	3
- Incorrect billing	20.0	3	18.6	4
- Reservation lost	0.0	-	4.9	7
- Advertisement promise not met	4.2	8	3.9	8
2. Food & beverage:				
- Food and beverage quality problem	36.8	2	29.4	2
3. Hygiene:				
- Poor cleanliness	15.8	5	9.8	6
- Untidy/unkempt staff	5.3	7	0.0	-
4. Behavior:				
- Unfriendly and unhelpful staff	15.8	5	16.7	5
5. Physical evidence:				
- Lacking in ambience	7.4	6	0.0	-

[a]Data are taken from **[12]**

2.1.2 Relationship between the waiting time for service and customer satisfaction

Lee, W. and Lambert, C.U. [13] represented waiting as the time from when customers get ready to be served to the time when customers get the full services from the service providers. Due to the difficulty in optimizing service quality and productivity, the optimal management of waiting time and service quality are challenging in food service industry. Dube-Rioux, L. et al. [14] reported the need for food service managers to try to continuously improve efficiency and quality of service to satisfy their customers' needs, which could also increase the competitive advantage over their rival businesses. The improvement in service quality is the main innovative way to satisfy customers by responding to the customer's expectations. One of the most important concerns for many restaurants is managing the waiting line for their customers. Many restaurants lose their customers as the waiting line for customers to be seated and served becomes too long.

Noone, B. and Kimes, S.E. [15] suggested that the service of restaurant could be divided into three stages of pre-process, in-process and post-process stages. The pre-process stage refers to the period from when customers first arrive at a restaurant until they have had their food order taken. The in-process stage includes the time from taking an order to serving an order and eating a meal. The post-process stage is the time from finishing a meal to when customers leave a restaurant and includes the payment process. They found that customers were not satisfied when they had to wait for a long time during the in-process or post-process stages. Thus, a restaurant should strive to avoid or minimize the waiting line during the in-process and post-process stages to minimizing the effect of waiting time on customer satisfaction.

2.1.3 Restaurant business process

Business processes are commonly used in many organizations, including in restaurants, retail stores, banks and hospitals, to represent a collection of activities or tasks that produce a specific product or service for a particular customer or customers. The process has been defined as “a set of activities that, taken together, produces a result of value to a customer” [16] and as “a set of logically related tasks performed to achieve a defined business outcome” [17].

The restaurant business is popular because people need to consume food every day to live yet many do not have time or inclination to prepare and cook food every day. In addition, it is a socially and culturally entertaining event. Therefore, it is a necessary business and worth the investment. Laube, J. [18] said: “It's no secret that many new restaurant owners find themselves faced with moderate and even severe challenges when turning their restaurants into successful businesses”. Indeed, to create the best business opportunities, the first objective is to build a set of instructions for all operations in the restaurant. It should begin with the process of analyzing every operational function of the restaurant from purchasing, preparing, cooking, cleaning and servicing. The most significant process is the service process, which is responsible for customer satisfaction and can guarantee they will return [18].

The restaurant process can be categorized in terms of the service into the four distinct stages: reception, ordering, meals and checkout [19], which can be measured as the reactions of the customers in the four service stages of greeting and seating, order taking and delivery, consumption and payment and exiting [20]. Each stage is defined as follows:

Stage 1: Greeting and seating. This stage starts from the time a customer is greeted by the host and lasts until a customer is assigned to a table.

Stage 2: Order taking and delivery. This stage begins when a customer is seated, and includes taking their drinks and food order, and lasts until the first food course is delivered to the table.

Stage 3: Consumption. This stage begins when a customer receives their food and continues until either a customer requests the bill or a waiter automatically delivers the bill.

Stage 4: Payment and exiting. This stage begins either when a customer requests the bill or a waiter automatically delivers the bill and continues until the bill payment transaction is completed and a customer vacates the table.

2.1.4 BPI methodology

The BPI is a fundamental business process management that is aimed at identifying those operations that could be improved to support a more efficient workflow overall. The common stages in different frameworks of BPI research methodology were previously proposed as seven distinct steps [21], as set out in Figure 1.

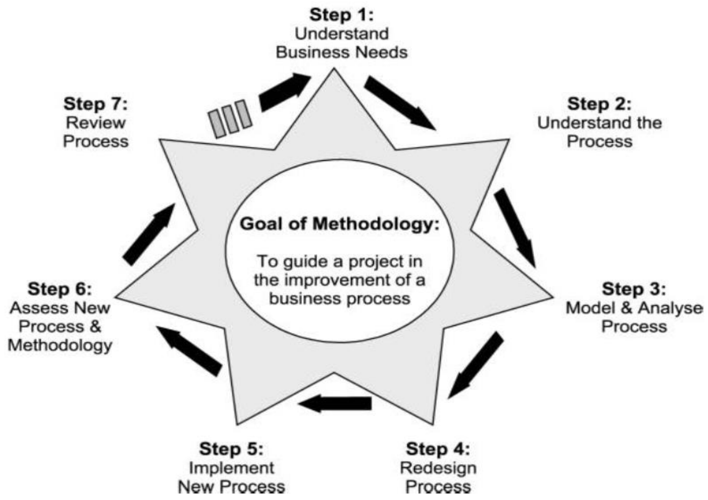

Figure 1. The BPI methodology

2.1.5 Process redesign

Hammer, M. [22] suggested that “in order to achieve significant benefits, it is not sufficient to computerize the old ways, but a fundamental redesign of the core business processes is necessary”. The fundamental redesign of the core business process enables the organization to renovate the business process by identifying which activities are redundant and can be removed, and grouping similar activities together [23-25]. The top ten redesign heuristics found by Mansar, S.L. and Reijers, H.A. [26] are shown in Table 2. There are various ways to improve the process.

Table 2. The top ten redesign heuristics[a]

Best practice	Definition
1. Task elimination	Eliminate unnecessary tasks from a business process
2. Task composition	Combine small tasks into composite tasks and divide large tasks into workable smaller tasks
3. Integral technology	Try to elevate physical constraints in a business process by applying new technology
4. Empower	Give workers most of the decision-making authority and reduce middle management
5. Order assignment	Let workers perform as many steps as possible for single order
6. Sequencing	Move tasks to more appropriate places
7. Specialist-generalist	Consider making resources more specialized and more generalist
8. Integration	Consider integration with a business process of the customer or a supplier
9. Parallelism	Consider whether tasks may be executed in parallel
10. Numerical involvement	Minimize the number of departments, groups and persons involved in a business process

[a]Data are from [26]

2.1.6 Measures used for process performance characteristics

The common measurements that can be used in a process performance have been reviewed [27], and are shown in Table 3. These measurements can be used to analyze the business process performance according to the objective of each organization. For example, time can be used as the measurement of the speed in analyzing the service process performance. The four most common measurement used were cost, time, quality and efficiency, since they are easy to measure and simple to use [27].

Table 3. Summary of the common process performance measurements[a]

Examples of measures used	
Cost cutting	Service and speed
Reducing the process time	Serviceability
Number of process activities	Flexibility
Mission	Quality of work life
Customer value	Perceived quality
Efficiency	Empowerment
Quality	Lead-time
Time	Robustness
Features	Customer satisfaction
Reliability	Growth
Conformance	Strategic measures
Durability	

[a]Data are from [27].

2.2 Related theory

To achieve the organization's objective and competitive advantage, each organization has to continuously improve their process. One important theory is BPI methodology, the related theory that is used to support the business process improvement. This simulation tool can also help improve the analysis of the performance of the system or process before it is implemented in the real situation. The principal of the simulation is to evaluate the required decisions in building the new system or process so as to improve the existing system or process without interfering with the actual process. The theories are as follows:

2.2.1 Business process model

The business process model is represented as a set of activities that have the purpose of achieving the organization's goal and creates an output in the form of a product or service to customers. A summary of the work is considered as the process performance, while the results of the operations for each process are based on the individual actions of the person in that process. The processes can be simple or complex depending on the size of the organization. The organization will define the roles and relationships between the activities to be performed in one process.

There are three types of business processes, as follows:

(1) *Management processes:* are the process of controlling the organization of the system, such as corporate governance and strategic management.

(2) *Operational processes*: are the most important type of processes in any organization. They are considered to be the core business activities, including purchasing, manufacturing and sales.

(3) *Supporting processes*: are the processes that support the day-to-day operation or the core business, such as accounting, technical support or recruitment.

2.2.2 Elements of the business process model

Business process models consist of the graphical objects that are used to construct a diagram to represent the flow of business process activities. The model can help describe the business process so as to make it more easily understood by the business user. The following are short descriptions and example figures of the objects used in the business process model.

(A) Flow objects

○An event denotes something that happens, such as customers have entered into the restaurant (Figure 2).

○Activity denotes the kind of work that has to be done, such as enter the food order (Figure 3).

○A gateway describes the merging of paths under the conditions expressed conditions (Figure 4).

(B) Business objects are the artifacts that are used to represent some information (Figure 5).

(C) Resources are the human or system that performs each activity in the process.

(D) Connecting objects are the connector that is used to connect the events, activities, gateways, business objects and resources to perform in one process (Figure 6).

(E) An example of a business process model is shown in Figure 7

Figure 2. Example of events

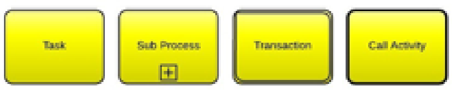

Figure 3. Example of activities

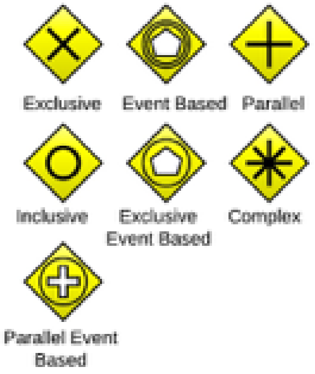

Figure 4. Example of gateways

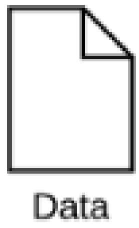

Figure 5. Example of a business object

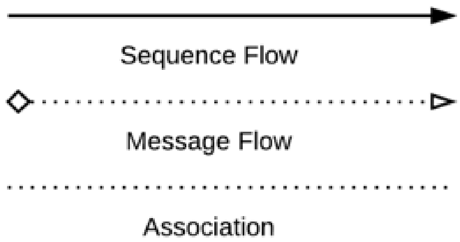

Figure 6. Example of connecting objects

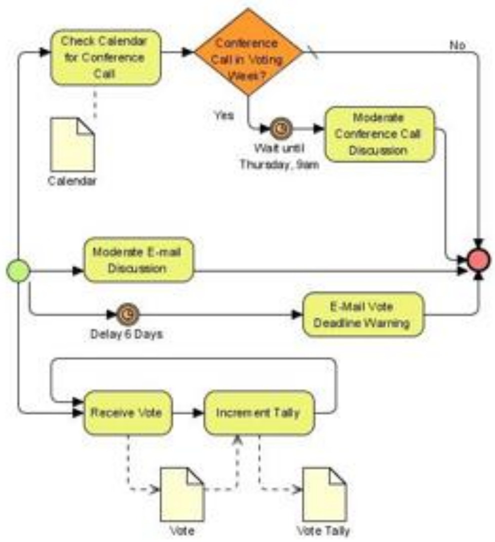

Figure 7. An example of a business process model

2.2.3 The BPI model

The BPI is a fundamental business process management tool aimed at identifying the operations that could be improved to support a more efficient workflow in the overall processes. The improvements in a business process of an organization are improving the quality, productivity and response time and reducing costs by removing non-value adding (NVA) activities. These can be summarized in three parts (Figure 8). The first part is to understand the AS IS process, which determines the detailed simulation data of the AS IS process. The second stage identifies potential improvements by analyzing the problem using timing analysis from the process that changes the input into output of the AS IS process. The last stage is the design concept of TO BE process. This stage determines the detailed simulation data of the TO-BE process compared with the AS IS process.

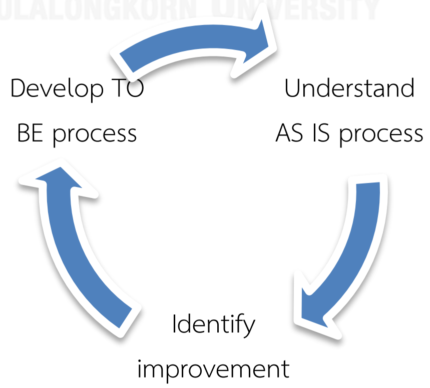

Figure 8. The iterative concept of stages of the BPI model

2.2.4 Value-added analysis

The goal is to ensure that the value of the product or service exceeds the cost of producing or providing the service. To remain viable and competitive, organizations have to examine each activity in their process, and classify the value-added component of their activities in turn. In general, they should be a positive value, or at least that the value covers the satisfaction of the customers.

The activities in the business process are examined by value-added analysis, which is the classification from the customer's perspective, and simply classifies the activities as value adding (VA), business value adding (BVA) and non-value adding (NVA) activity. These are explained in turn as follows. Firstly, VA activities are those that contribute to satisfy the customer's satisfaction and improve the customer's perception of the product or service, such as taking the order, receiving the menu, advice and the ordered food and drinks. Secondly, BVA activities are those that are necessary for the business or governance, such as checking and controlling events. Lastly, NVA activities are those that are not requires or are a waste, in terms of that they do not contribute to the customer's and business requirement. They are hence the activities that can be removed from the process.

2.2.5 The BPsimulation

The BPsimulation is a tool for analyzing the business processes that is used to assess the dynamic behavior of the processes over time. The results allow decisions in the process design or resource provision that aim to improve factors, such as process performance, process and product quality and resource utilization. By running simulations, companies can predict how business processes perform under specific conditions and so help predict optimal responses to future changes. Process simulation can identify the most effective process flow and help to prevent problems from cropping up during the process execution.

Examples of the application of the simulation model are diverse, and include in (a) industry systems, such as queuing, manufacturing and communication systems; (b) business and economic systems, such as the behavior of consumers and the market situation; (c) aircraft systems, including the simulation of different scenarios that are used in training aircraft; and (d) traffic systems, such as simulating the timing of a turn signal light.

The three main advantages of simulation are (i) the ability to repeatedly simulate each case at any time under given conditions, (ii) a cheaper cost and less time required for performing tests than in the real system and (iii) as a tool for training in a dangerous situation before the actual situation.

However, simulation has the two limitations of simulation (i) that the results of the simulation are only estimation and (ii) that although it can actually analyze the system or process, it does not guarantee the accuracy of the result.

CHAPTER 3

RESEARCH METHODOLOGY

This research applied the BPI methodology with process redesign heuristics to integrate the simulation as a way of measuring the influential parameters affecting the response time and slow service. The number of parameters was adjusted to improve the process performance characteristics. The methodology consisted of three steps as shown in Figure 9. The first and second steps were adapted from the BPI methodology used by Baines, T., and Adesola S. [21] to identify the current process and design the new process. In third step, simulation technique was used to analyze the process performance whether or not it could be improved as redesign the current process, which was redesigned using proper parameters of the simulation tool [5]. Details of each step are described below.

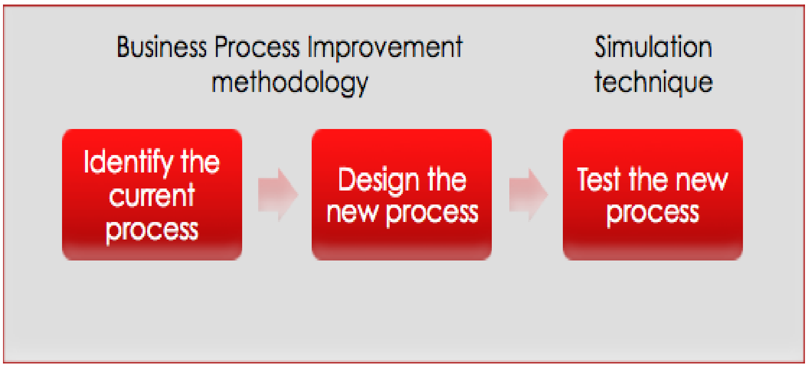

Figure 9. Overview of the proposed methodology

3.1 Business process improvement methodology

(i) Identify the current process

The first step creates a process model of the current conditions in the work activities to be able to identify how the existing process really operates and whether the current situation is in line with the original goals and objectives of the process. During this stage, activities that have become outdated or irrelevant should be considered and removed at the next stage. To find which activity is not necessary for the current process, the value-added analysis was used to classify each activity in VA, BVA or NVA activities as shown in Figure 10. It is the diagram that uses to make decision for classifying activity. VA defines as the necessary activities of the process that meet customer's expectations. BVA refers to the essential activities for conducting business that add cost to the process but do not add any value from customer's view. NVA is the unnecessary activities that neither conduct business nor add value to customer's view.

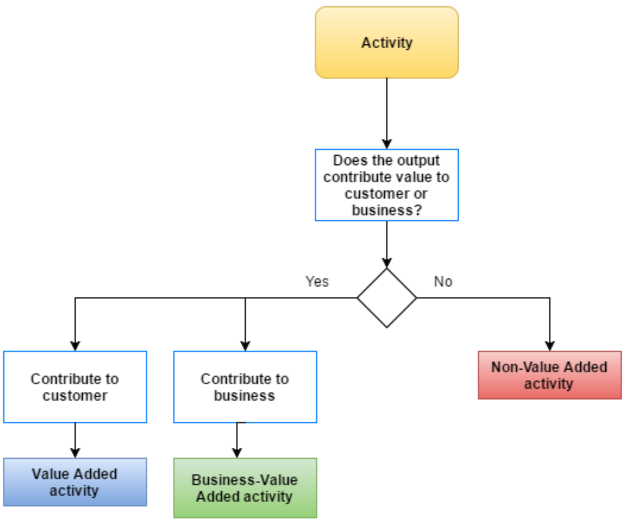

Figure 10. The value-added analysis approach

(ii) Design the new process

After identifying the current process, a process model and classification of process activity are constructed. The second step involves selection of specific improvements to the current process and implements these to form the new process by identifying various ways to improve the process using the top ten-redesign heuristics [26]. In order to improve the current situation, this work eliminates unnecessary activities and applies the redesign heuristics to create new processes. Redesigning the new process in this research refers to the process redesign heuristics of Mansar, S.L. and Reijers, H.A. [26] as shown in Table 4.

Table 4. The process redesign heuristics[a]

Best practice	**Definition**
1. Task elimination	Eliminate unnecessary tasks from a business process
2. Task composition	Combine small tasks into composite tasks and divide large tasks into workable smaller tasks
3. Integral technology	Try to elevate physical constraints in a business process by applying new technology
4. Empower	Give workers most of the decision-making authority and reduce middle management
5. Order assignment	Let workers perform as many steps as possible for single order
6. Sequencing	Move tasks to more appropriate places
7. Specialist-generalist	Consider making resources more specialized and more generalist
8. Integration	Consider integration with a business process of the customer or a supplier
9. Parallelism	Consider whether tasks may be executed in parallel
10. Numerical involvement	Minimize the number of departments, groups and persons involved in a business process

[a]Data are from [26]

3.2 Simulation technique

(iii) Test the new process

The last step is the simulation to ensure that the new process improves the performance, product and service quality, and resource utilization. The input for the business process simulation is comprised of information flow, resources, and instantiation. The results of the business process simulation are the quantitative, time-based, and cost-related information concerning the execution and resource usage.

The input parameters used to measure the performance of the new process are shown in Table 5. All input parameters based-on the BPsimulation tool [5] and those of previous research [23] are compared. However, in this research, the adjustable parameters indicate decision variables, where the number of resources affects the performance characteristics of the process. All other input parameters are defined as fixed variables.

Table 5. Comparison of the input parameters used in the simulation and that in [23].

Input	Isa Muslu [23]	In this research
Duration of each task		X
Time of delivery task		X
Operating period	X	X
Cost of operating the process		X
Pay rate hours		X
Probabilities distribution		X
Number of resources		X
Number of tasks created		X

The process performance measurements of this study and those of a previous study [23] are shown in Table 6, where the additional characteristics of the service process used in this study are proposed. For this research, the process performance characteristics in terms of cost, time, and quality are shown in Table 7, and are selected according to the review of Kallio et al. [27].

Table 6. Comparison of the considered process performance measurement

Performance	Al-Mashari [23]	This research
Queue time	X	X
Task completed		X
Cost of operating the process	X	X
Cycle time		X

Table 7. Process performance measurement

Measure used for the process performance characteristics	
Cost	- Cost of operating the process
Time	- Cycle time
	- Queue time
Quality	- Task completed

The control panel of the BPsimulation tool [5] of the simulation is shown in Figure 11. It contains the initial setting and buttons controlling for simulating the process. The description of simulation objects and their properties which are used to construct the simulation model are shown in Table 8 and Table 9, respectively. The simulation collects business process data such as queue time, cycle time, cost of operating the process, and task completed. The summary report is shown in Figure 12.

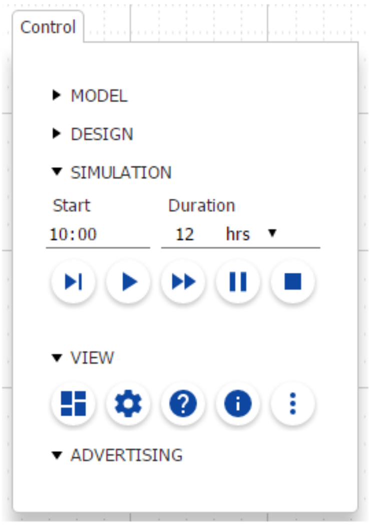

Figure 11. Simulation control panel

- Initial settings
  - Start - starting time of the process in the a simulated environment
  - Duration - the duration of the simulation to the time scale of the process
- Control buttons
  - Next - moving to next time period of the process
  - Run - automatic gradual moving to the next time period for the duration of the simulation
  - Forward - similarly Run operation with acceleration
  - Pause - pause of automatic moving to the next time period
  - Stop - full stop of the current simulation

Table 8. The simulation model object

Object	Description	Properties
	Task generator of the business process for the simulation purposes	- Name - Operating periods - Task created
	The targeted functions or activities to be performed by one or more executers	- Name - Duration time - Probability distribution of task consumers
	Position of those who responsible for executing the function	- Name - Cost of using the resource - Number of employee - Operating periods
	An intangible result of a function	- Name

Table 9. The simulation object properties

Property	Description	Type
Name	Text description of the object	Text
Task created	The number of tasks formed by the generator at a certain period of work.	Number
Operating periods	The time period available resources to perform the functions	Range
Duration time	The minimum and maximum duration time of the function or activity	Number
Probability distribution of task consumers	Percentage that determines the probability distribution of tasks to a consumer of the function.	Number
Cost of using the resource	Pay rate hours of operation of the resource.	Currency unit
Number of employee	The actual number of staff positions in the organizational structure or appointed as an executive of the functions.	Number

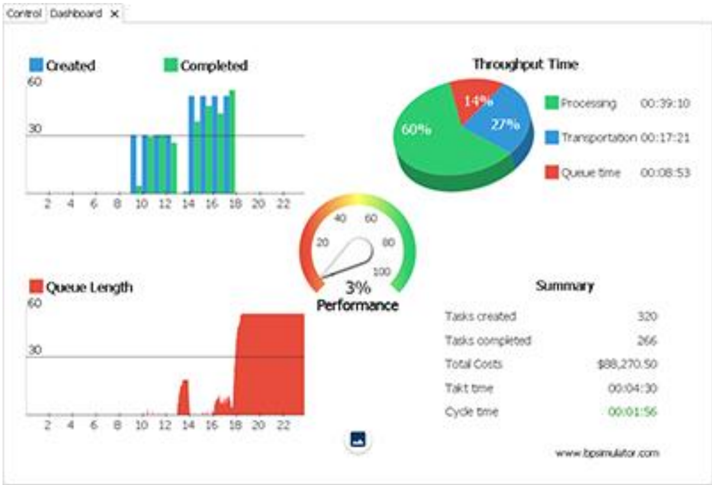

Figure 12. The simulation report summary

3.3 Performance characteristics

This work uses four performance characteristics as the measurement of quality of the process, there are provided by simulation tool. The four main performance characteristics are shown as following;

(i) Minimizing the cost of operating the process that is the cost of resources during the operating of the process.

(ii) Minimizing the queue time which is the average amount of time spent to the waiting of task processing.

(iii) Maximizing the number of tasks completed that the process can handle in the available time.

(iv) Minimizing the cycle time which is the average period between tasks that have reached the end of a business process.

CHAPTER 4

CASE STUDY AND EXPERIMENTAL RESULTS

In this chapter the application of the research methodology to a case study for restaurant businesses of three different sizes, is presented. The BPI research methodology was applied at each step of the restaurant service process to improve the process and determine the performance of the process through adjustment of the resources in the simulation tool.

4.1 Case study

Step 1: Identifying the current process

The service activities in the case study restaurants were identified as the current process, as summarized in Figure 13. Firstly, the hostesses have to check the table availability for the customers when they enter the restaurant. If there is no table available, the customers have to wait. When a suitable table is available, the hostesses will select a table and seat the customers. After seating, a waiter will take the orders and send it to the chefs. The chefs then prepare the food to order. When the food is ready to be served, the waiters will delivery it with the drink (if any) to the customers. After the customers finish eating, the waiter will deliver a bill to the customers. Lastly, the waiter will collect the money and provide a receipt to the customers.

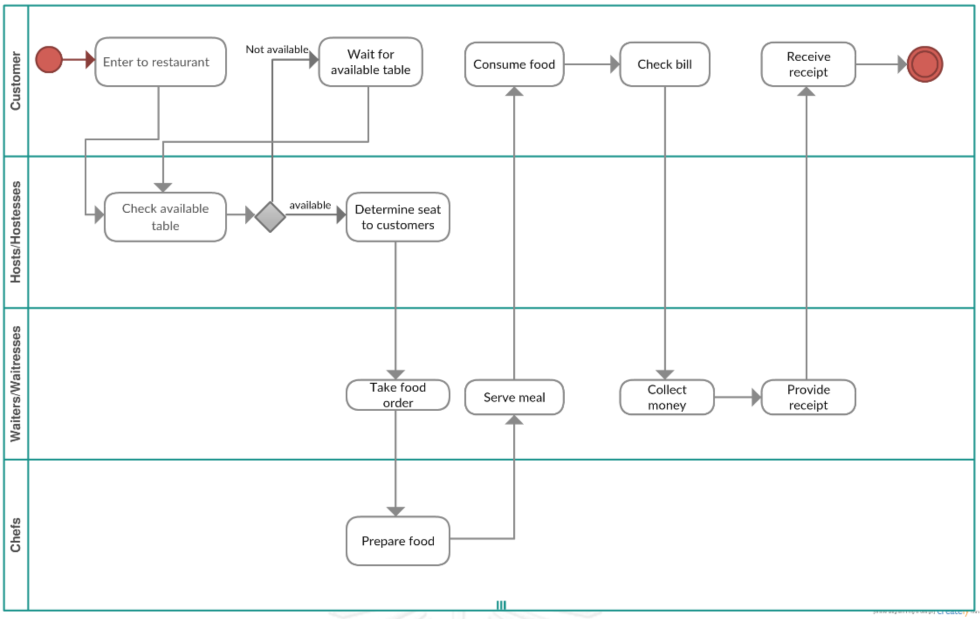

Figure 13. Business process model of the current process (AS-IS)

The value-added analysis was then applied to eliminate any wasted activities presented in the current process. Each of the related activities was classified as being VA, BVA or NVA activities as appropriate (Table 10). Any NVA activities were eliminated.

Table 10. Classification of value-added analysis

Activity	Classification
Check for an available table	BVA
Determine seat to customer	VA
Take food order	VA
Prepare food	VA
Serve meal	VA
Deliver bill and collect money	VA
Provide receipt	NVA

Step 2: Design the new process

In order to improve the current process, the re-design heuristics [26] were applied to the current process.

Task elimination: Providing a receipt was eliminated since this activity was determined to be a NVA activity from the customer's point of view. Its absence can increase the processing speed and reduce the resource costs. Thus, the new process, which was expected to improve the service process in terms of reducing the queue time, cycle time of process, and the number of tasks completed, is shown in Figure 14.

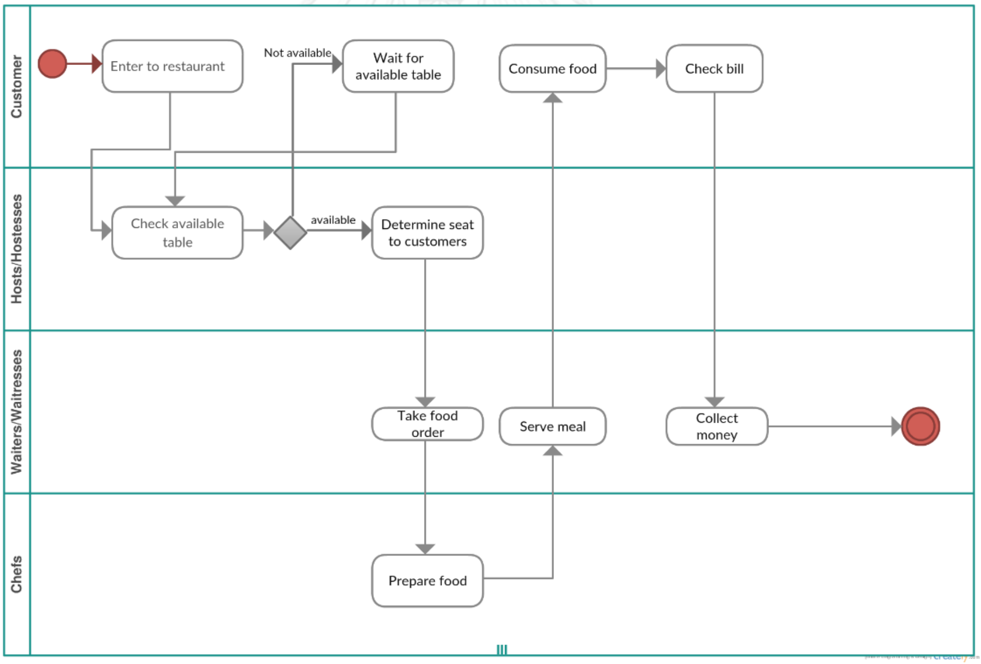

Figure 14. Business process model of the new process (TO-BE)

Step 3: Test the new process (TO-BE process)

Since this research focuses on the steps or activities relating to the employees, it does not cover customer-related activities. The flow diagram of the process contains the steps and resources that are the response from each service process in the simulation tool for the current and the new processes (Figure 15, 16).

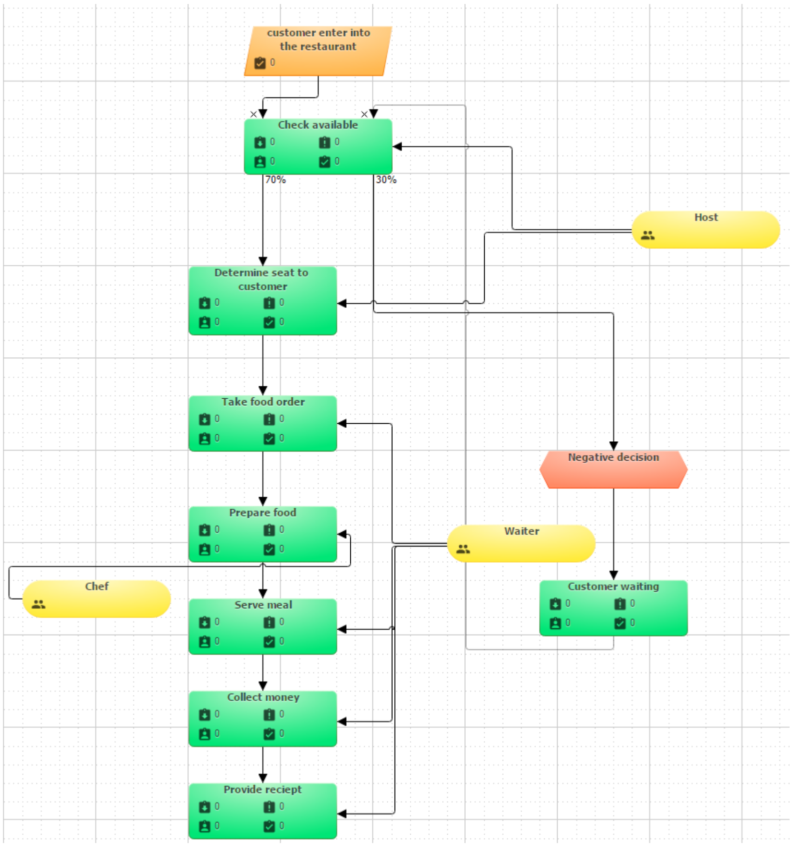

Figure 15. Flow diagram of the current process

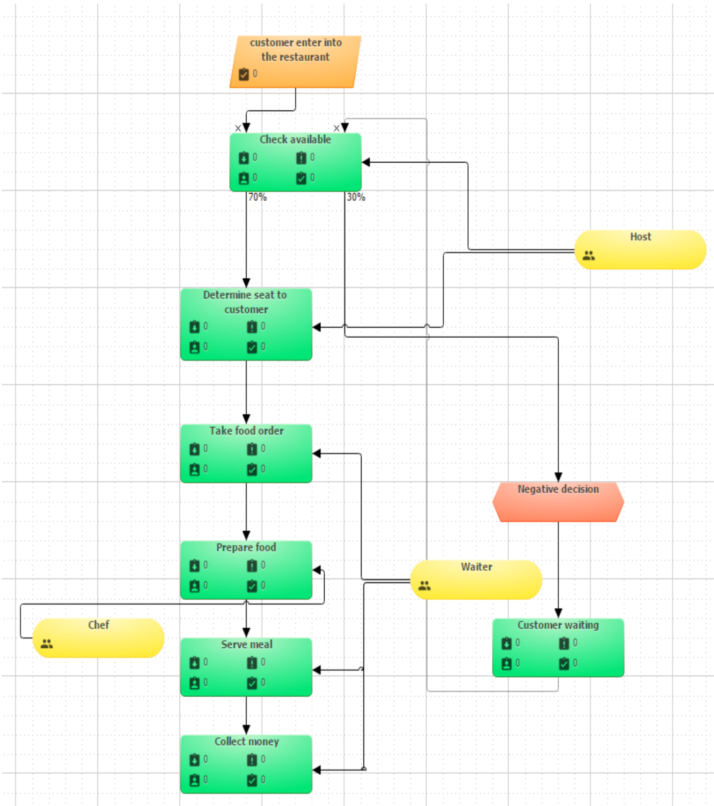

Figure 16. Flow diagram of the new process

4.1.1 Input parameters of the process

The input parameter of each activity in the simulation tool was processed according to the flow diagram of the current and the new processes (Figure 15, 16) for three different restaurant sizes, namely, small, medium, and large. Each restaurant had its own input. The input parameters of each activity were the activity name (name of each task that was performed), resource (who performs that operation) and duration time (the process time of each activity from the minimum time to the maximum time). The input parameters expressed in duration for the three different sized restaurants are summarized in Table 11. For each size of restaurant, the pay rate per hour of the hostesses, waiters, and chefs are fixed as 30, 35 and 50 baht, respectively, based on the minimum hourly rate of real situation.

Table 11. Input parameters for the BPsimulation tool

	Activity name	Resource	Duration time
Small-size restaurant	Check for available table	Host	1-5 minutes
	Customer waiting	-	1-15 minutes
	Determine seat to customer	Host	1-5 minutes
	Take food order	Waiter	3-5 minutes
	Prepare food	Chef	5-15 minutes
	Serve meal	Waiter	1-5 minutes
	Collect money	Waiter	1-5 minutes
	Provide receipt	Waiter	1-3 minutes
Medium-size restaurant	Check for available table	Host	1-5 minutes
	Customer waiting	-	1-20 minutes
	Determine seat to customer	Host	1-5 minutes
	Take food order	Waiter	3-10 minutes
	Prepare food	Chef	10-20 minutes
	Serve meal	Waiter	1-5 minutes
	Collect money	Waiter	1-5 minutes
	Provide receipt	Waiter	1-3 minutes
Large-size restaurant	Check for available table	Host	3-5 minutes
	Customer waiting	-	1-30 minutes
	Determine seat to customer	Host	1-5 minutes
	Take food order	Waiter	3-10 minutes
	Prepare food	Chef	10-30 minutes
	Serve meal	Waiter	1-10 minutes
	Collect money	Waiter	1-5 minutes
	Provide receipt	Waiter	1-5 minutes

4.2 Results

4.2.1 Simulation results

The results from simulation for the current and the new processes in the three different sized restaurants are summarized below. In the simulation, the number of resources (staff) was adjusted to analyze the performance of the process, in terms of the number of tasks completed, customer queue time, cycle time, and cost of operating the process. Note that for all three simulations (small-, medium- and large-sized restaurants) the iterations were based upon a sequential univariate approach to find the optimal number of waiters, chefs, and hostesses (resources), in that order, which assumed these were independent factors with no interaction between them.

(A) Small-sized restaurants (50 task created/12-h day)

In small-sized restaurant, the results were considered only one round because a small-sized restaurant did not need to assign a large number of staff. The maximum number of staff was set at six persons, and the number of tasks created was fixed at 50 which were generated by task generator for all iterations per 12-h opening day (10:00–22:00 h).

The simulation results for both the current and the new processes are shown in Tables 12 and 13, respectively. The average queue time and cycle time of the new process were better than the current process when the number of resources were increased at two hostesses, two waiters, and two chefs. The average queue time and cycle time in the new process had less time when compared to the current process, and the number of tasks completed matched that created. However, in the new process, if considering only the cost, the best solution was one hostess, two waiters, and one chef. So, it could be concluded in two ways. First, the optimal number of staff was determined to be two hostesses, two chefs, and two waiters for this small-sized restaurant in terms of the average queue time, cycle time, and task completed, and second, the optimal number of staff in terms of cost was defined as one hostess, two waiters, and one chef.

Table 12. Simulation results for the current process for the small-sized restaurant

Hostess	Waiter	Chef	Tasks created	Tasks completed	Cycle time (min:s)	Avg. queue time (min:s)	Cost of operating the process (Thai bahts)			
							Hostess	Waiter	Chef	Total
1	1	1	50	47	14:31	16:01	193.0	337.7	388.9	920.2
1	2	1	50	47	14:36	04:02	192.1	347.3	451.4	991.0
2	1	1	50	47	14:42	14:01	203.3	342.0	409.9	955.0
1	1	2	50	49	14:12	19:19	212.2	331.2	378.1	922.1
2	**2**	**2**	**50**	**48**	**14:34**	**01:02**	**222.6**	**333.8**	**407.9**	**964.2**

The bold text highlights that the best number of resources in the process.

Table 13. Simulation results of the new process for the small-size restaurant

Hostess	Waiter	Chef	Tasks created	Tasks completed	Cycle time (min:s)	Avg. queue time (min:s)	Cost of operating the process (Thai bahts)			
							Hostess	Waiter	Chef	Total
1	1	1	50	47	14:22	07:32	220.6	286.4	394.3	901.3
1	2	1	50	48	14:25	04:58	213.6	264.8	399.0	877.3
2	1	1	50	48	13:57	06:11	208.8	278.0	403.2	890.0
1	1	2	50	47	14:57	06:19	206.4	279.2	405.5	891.2
2	**2**	**2**	**50**	**50**	**13:45**	**00:24**	**207.2**	**282.0**	**397.5**	**886.7**

The bold text highlights that the best number of resources in the process.

(B) Medium-sized restaurant (120 task created /12-h day)

In the medium-sized restaurants, the simulation results were presented after three rounds, in which the number of tasks created was fixed at 120 which were generated by task generator per 12-h opening day (10:00– 22:00 h).

In the first round, the number of hostesses and chefs was fixed at two each and the number of waiters increased from two to six to find the effect on the process. In the second round the optimal number of waiters found in the first round was fixed, along with two hostesses. The number of chefs varied from two to six. Finally, in the third round the optimal number of chefs and waiters was kept constant while the number of hostesses increased from two to six.

The simulation results for the current and the new processes are summarized in Tables 14 and 15, respectively. In terms of the number of tasks completed, cycle time and the average queue time, both the current and the new processes were quite similar. However, the new process offered a better cost saving than the current process, since it used a lower number of staff than the current process. From the simulation of the new process, the optimal staff level was two hostesses, four waiters, and six chefs in the second round. When increasing the number of chefs indicated that it affected performance of the process, number of tasks completed increased to 115 of 120 tasks created from 95 in the first round. The optimal staff level was five hostesses, four waiters, and six chefs in the third round, giving an improved performance in terms of the number of completed tasks, reduced cost, average queue time, and cycle time.

Table 14. Simulation results of the current process for the medium-sized restaurant

Hostess	Waiter	Chef	Tasks created	Tasks completed	Cycle time (h:min:s)	Avg. queue time (h:min:s)	Cost of operating the process (Thai bahts)			
							Hostess	Waiter	Chef	Total
2	2	2	120	46	0:12:43	2:18:55	486.4	811.8	1,171	2,469.3
2	3	2	120	90	0:07:39	1:10:22	489.1	878.7	1,168	2,536.1
2	4	2	120	91	0:07:30	1:01:01	487.0	862.6	1,194	2,543.4
2	5	2	120	91	0:07:33	1:02:08	484.1	878.2	1,178	2,540.6
2	6	2	120	95	0:07:15	1:02:00	495.7	879.9	1,165	2,540.4
2	6	3	120	113	0:06:05	0:05:36	516.0	965.1	1,513	2,994.4
2	6	4	120	112	0:06:11	0:07:10	529.4	999.6	1,457	2,986.1
2	6	5	120	114	0:06:01	0:04:46	509.3	988.5	1,475	2,972.7
2	6	6	120	112	0:06:04	0:07:55	487.2	986.5	1,458	2,931.8
3	6	5	120	112	0:06:00	0:03:27	491.9	977.9	1,381	2,851.3
4	6	5	120	114	0:06:04	0:03:03	518.1	989.6	1,474	2,981.8
5	**6**	**5**	**120**	**115**	**0:05:59**	**0:01:01**	**489.8**	**974.2**	**1,458**	**2,921.5**
6	6	5	120	115	0:06:02	0:01:02	464.1	1,008.7	1,409	2,881.8

The bold text highlights that the best number of resources in the process.

Table 15. Simulation results of the new process for the medium-sized restaurant

Hostess	Waiter	Chef	Tasks created	Tasks completed	Cycle time (h:min:s)	Avg. queue time (h:min:s)	Cost of operating the process (Thai bahts)			
							Hostess	Waiter	Chef	Total
2	2	2	120	91	0:07:35	1:22:04	506.3	788.7	1,180.2	2,475.2
2	3	2	120	91	0:07:28	1:09:01	484.8	767.8	1,179.4	2,432.0
2	4	2	120	95	0:07:11	0:55:35	509.0	754.1	1,167.7	2,431.0
2	5	2	120	92	0:07:26	1:06:58	503.4	771.3	1,158	2,432.4
2	6	2	120	90	0:07:40	1:20:43	501.6	743.4	1,163.7	2,408.7
2	4	3	120	113	0:06:05	0:03:36	499.1	868.8	1,479.5	2,847.4
2	4	4	120	114	0:06:01	0:02:08	512.2	867.5	1,446.6	2,826.4
2	4	5	120	112	0:06:11	0:01:04	529.9	828.7	1,434.9	2,793.5
2	4	6	120	115	0:06:00	0:01:22	525.7	844.4	1,424.2	2,794.2
3	4	6	120	114	0:05:58	0:00:17	526.8	830.2	1,442.5	2,799.4
4	4	6	120	113	0:06:01	0:00:25	505.5	873.1	1,475.9	2,854.6
5	**4**	**6**	**120**	**115**	**0:05:57**	**0:00:11**	**486.9**	**853.9**	**1,461.1**	**2,801.9**
6	4	6	120	113	0:06:08	0:00:21	509.4	833.8	1,496.3	2,839.5

The bold text highlights that the best number of resources in the process.

(C) Large-sized restaurant (300 task created /12-h day)

For the large-sized restaurants, the results were shown for three rounds in the same manner as those for the medium-sized restaurants. The number of tasks created was fixed as 300 which were generated by task generator for all rounds per 12-h opening day (10:00–22:00 h).

In the first round, the number of hostesses and chefs was fixed at two each and the number of waiters increased from two to six to find the effect on the process. In the second round the optimal number of waiters found in the first round was fixed, along with two hostesses, and the number of chefs varied from two to six. Finally, in the third round the optimal number of chefs and waiters was kept constant while the number of hostesses increased from two to six.

The simulation results for the current and the new processes are summarized in Tables 16 and 17, respectively. In terms of the number of tasks completed and cycle time, the current and the new process were essentially the same. However, the new process was better than the current one in having a shorter average customer queue time and a lower cost. From the simulation of the new process, the optimal number of staff found for a large-sized restaurant was seven hostesses, nine waiters, and eleven chefs in the third round, giving an improved performance in terms of task completed with 280 tasks completed that almost matched task created, and shorter average queue time and less cost than the best result of the second round.

Table 16. Simulation results of the current process for the large-sized restaurant

Hostess	Waiter	Chef	Tasks created	Tasks completed	Cycle time (h:min:s)	Avg. queue time (h:min:s)	Cost of operating the process (Thai bahts) Hostess	Waiter	Chef	Total
4	7	7	300	215	0:03:07	1:08:30	1,496.8	2,618.9	4,059.9	8,175.6
4	8	7	300	225	0:03:01	1:00:11	1,509.5	2,624.6	4,037.8	8,171.9
4	9	7	300	235	0:02:51	0:58:00	1,462.3	2,684.8	4,078.3	8,225.4
4	10	7	300	231	0:02:55	0:59:38	1,464.5	2,675.2	4,057.6	8,197.3
4	11	7	300	240	0:02:48	0:42:07	1,483.0	2,660.0	4,106.0	8,249.0
4	11	8	300	263	0:02:35	0:21:04	1,450.1	2,901.3	4,580.0	8,931.4
4	11	9	300	270	0:02:31	0:12:02	1,500.2	2,978.4	4,689.5	9,168.1
4	11	10	300	275	0:02:26	0:10:39	1,522.9	2,915.1	4,754.2	9,192.3
4	11	11	300	277	0:02:25	0:09:41	1,516.3	2,961.4	4,735.7	9,213.4
4	11	12	300	276	0:02:27	0:06:34	1,476.0	3,014.3	4,891.6	9,382.0
5	11	11	300	273	0:02:29	0:01:14	1,519.1	2,995.9	4,840.5	9,355.5
6	**11**	**11**	**300**	**277**	**0:02:26**	**0:01:06**	**1,496.0**	**2,997.9**	**4,853.8**	**9,347.7**
7	11	11	300	276	0:02:25	0:01:09	1,556.2	2,936.4	4,919.1	9,411.7
8	11	11	300	274	0:02:28	0:01:08	1,523.2	2,920.0	4,819.0	9,262.2

The bold text highlights that the best number of resources in the process.

Table 17. Simulation results of the new process for the large-sized restaurant

Hostess	Waiter	Chef	Tasks created	Tasks completed	Cycle time (h:min:s)	Avg. queue time (h:min:s)	Cost of operating the process (Thai bahts) Hostess	Waiter	Chef	Total
4	7	7	300	235	0:02:53	0:57:08	1,475.8	2,295.3	4,062.8	7,833.9
4	8	7	300	232	0:02:53	0:53:28	1,513	2,294.5	4,048.7	7,856.3
4	9	7	300	241	0:02:50	0:52:46	1,470.7	2,310.7	4,032.5	7,813.9
4	10	7	300	234	0:02:52	0:52:58	1,460.9	2,213.1	4,097.1	7,771.1
4	11	7	300	230	0:02:56	1:00:39	1,417.3	2,225.8	4,114.7	7,757.7
4	9	8	300	259	0:02:41	0:24:30	1,529.1	2,404.4	4,505.4	8,438.8
4	9	9	300	269	0:02:31	0:06:06	1,445.0	2,512.9	4,825.3	8,783.3
4	9	10	300	279	0:02:26	0:05:41	1,496.4	2,451.7	4,904.1	8,852.2
4	9	11	300	282	0:02:24	0:05:08	1,487.2	2,496.8	4,821.0	8,804.9
4	9	12	300	279	0:02:27	0:07:41	1,530.7	2,484.7	4,741.7	8,757.0
5	9	11	300	277	0:02:26	0:01:16	1,467.0	2,509.4	4,727.4	8,703.8
6	9	11	300	281	0:02:25	0:00:42	1,506.9	2,457.8	4,784.0	8,748.6
7	**9**	**11**	**300**	**280**	**0:02:26**	**0:00:26**	**1,429.4**	**2,487.6**	**4,707.2**	**8,624.2**
8	9	11	300	279	0:02:25	0:00:36	1,478.8	2,479.2	4,883.9	8,841.9

The bold text highlights that the best number of resources in the process.

4.2.2 Validation

The observed and simulation data were compared in order to test the apparent validity of the simulation results, as though the simulation were sufficient to analyze the real situation. The comparison focused on the average queue time when customers had to wait for their food in each of three different sized restaurants. In this stage, this research defines the average queue time as the average amount of time when customers waiting for chefs preparing their food, which is the same as the average queue time of performance characteristics, described in Chapter 3. The ABC restaurant was used as the observation of small-sized restaurant. There were three staff members. They had a limited amount of space in their restaurant, and could only serve around 50 customers per 12-h operating day (10:00–22:00 h). The observed medium-sized restaurant was KMN restaurant, which served approximately 80–150 customers per 12-h operating day (10:00–22:00 h). They employed one hostess, six chefs, and six waiters. Finally, the XYZ restaurant was used as the observed large-sized restaurant, which served around 200–300 customers per 12-h operating day (10:00–22:00 h) having two hostesses, seven chefs, and nine waiters.

The average customer queue time for each restaurant size is summarized in Table 18. The observed average customer queue time was low (6.63 min) in the small-sized restaurant, and increased about 1.9- to 3.3-fold in the medium- and large-sized restaurants, respectively. With respect to the simulated data, a broadly similar trend was seen although the customer queue time was much greater for the large-sized restaurant. For the small- and medium-sized restaurants, the observed queue time was numerically slightly (1.16- and 1.02-fold, respectively) smaller than the simulated data. But they were not significantly different. So the simulation model was potentially valid for the small- and medium-sized restaurants. However, for the large-sized restaurant, the simulated customer queue time was 2.22-fold and significantly longer than the observed time. So the simulation model was not applicable for this large-sized restaurant. The small-sized restaurant had a faster speed of service, while the customers spending less time waiting for food, compared to the medium and the large-sized restaurants.

Table 18. Comparison between the observed and simulated data

Restaurant size	Average queue time for waiting food		P-value[b]
	Observation (min)[a]	Simulation (min)	
Small-sized	6.63 ± 1.740428	7.69	0.293194124
Medium-sized	12.55 ± 2.116564	12.84	0.830247841
Large-sized	21.64 ± 5.064827	48.71	0.00000000000288850756

[a] Data are shown as the mean ± 1SD, derived from the observation days that totaled 10, 12 and 20 customers in the small-, medium- and large-sized restaurants, respectively. [b]Results of the statistical tests for difference between the observed and simulated data.

The simulation results are satisfied with small-size and medium size restaurant due to queue time are quite close to the observation. However, the simulation is not sufficient for large-size restaurant that serve 300 customers per day.

The validation uses a hypothesis test to find the difference between the simulation result $\boldsymbol{\mu_1}$ and the observation $\boldsymbol{\mu_2}$. Therefore, using the significance level α = 0.01.

$$H_0: \boldsymbol{\mu_1} = \boldsymbol{\mu_2}$$

$$H_1: \boldsymbol{\mu_1} \neq \boldsymbol{\mu_2}$$

A P-value for a hypothesis test with α

1. If $P \leq \alpha$, then reject H_0
2. if $P > \alpha$, then fail to reject H_0

The hypothesis result shows that the observation and the simulation result are not significantly different of queue time in small-sized and medium-sized restaurants. The p-value of small-sized restaurant is 0.293194124, which is failed to reject H_0. Also, P-value of medium-sized restaurant is 0.83024784. It's greater than the significance level, so fails to reject H_0. However, it shows the difference of queue time in large-size restaurant, P-value is 0.00000000000288850756 which is smaller than the significance level, and rejects H_0 to accepts H_1.

CHAPTER 5

CONCLUSION AND FUTURE WORK

In this chapter, the optimal number of resources in each size of the restaurant and the results of validation when compared with the simulation results are described. Some limitations and future work are also discussed.

5.1 Conclusion

This research studied the improvement of a business process by applying the BPI methodology with process redesign integrated with the BPsimulation tool [5] to adapt three different sized restaurants as a case study. The BPsimulation tool [5], which was used to measure the performance of the process, including the number of tasks completed, cost of operating the process, queue time and cycle time, was performed by adjusting the number of resources (staff) that affected the performance.

After redesigning the new process, it was shown that the performances of the process improved according to the adjustable parameters (resources) in the simulation tool. So, the simulation results found the appropriate number of staff of each type (hostesses, waiters, and chefs) required for different sized restaurants to maximize their performance and closely matched the observed results.

For small- sized restaurants (50 task created/12-h day), in terms of cost consideration, it was one host, two waiters, and one chef with 48 tasks completed of 50 tasks created, 14.25 minutes of cycle time, 4.58 minutes of average queue time, and 877.3 bahts of total cost. In terms of task completed, average queue time and cycle time, it was two hostesses, two waiters, and two chefs with 50 tasks completed, 13.45 minutes of cycle time, 0.24 minutes of average queue time, and 886.7 bahts of total cost.

For medium-sized restaurants (120 task created/12-h day), in terms of cost consideration, the optimal staffing was found to be two hostesses, four waiters, and six chefs with 115 tasks completed, 6 minutes of cycle time, 1.22 minutes of average queue time, and 2794.2 bahts of total cost. In terms of task completed, average queue time, and cycle time, it was five hostesses, 4 waiters, and 6 chefs with 115 tasks completed, 5.57 minutes of cycle time, 0.11 minutes of average queue time, and 2801.9 bahts of total cost.

For large-sized restaurants (300 task created/12-h day), in terms of cost consideration, the simulation results was four hostesses, 9 waiters, and 8 chefs with 259 tasks completed, 2.41 minutes of cycle time, 24.30 minutes of average queue time, and 8438.8 bahts of total cost. In terms of task completed, average queue time and cycle time, the simulation predicted an optimal staffing of seven hostesses, nine waiters and eleven chefs with 280 tasks completed, 2.26 minutes of cycle time, 0.26 minutes of average queue time, and 8624.2 bahts of total cost. In some cases, waiters and hostesses can be swapped their duties whenever needed.

According to the results in all sized restaurants, it implies that the performances of process vary depend on the number of resources. Task completed, cycle time and queue time are optimize when the number of resources are high but the cost of operating is high as well. Therefore, it depends on which performance is considered more important.

From the validation result, it shows that the comparison between the simulation result and the observation data can somewhat sufficiently analyze the real situation by using the hypothesis test. However, the simulated results for the large-sized restaurant do not match the observed data. It implies that the service process model satisfies for small and medium-sized restaurants, but may be not suitable for large-sized restaurant. Nevertheless, the simulation process does not lose time or money for application before adapting to a real situation, and may be beneficial for small- and medium-sized restaurants.

5.2 Future work

The limitation of this research is the amount of observation data collected from customers in the real situation, their efficiency changes overtime. So, one day for data collection may not be sufficient to compare with the simulation result. As the observation of one restaurant in each size with 10% of customers, it may not be valid for the observation data.

The future work is to analyze the service process for large-sized restaurant and observe more restaurants in vary period as peak-time and non-peak time in longer period to make the observation data more valid.

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VITA

Salinthip Somphanape, the author was born on October 12, 1991 in Bangkok, Thailand. She attended her elementary education at Narathorn elementary school. After that, she attended her High-school education at Wachirathamsatit School. In 2014, she graduated from Sirindhorn International Institution of Technology, Thammasat University in Bachelor degree of Computer Science. She completed a short internship program at Nippon Sysit Co.,LTD., Bangkok. After her graduation, she attended in Master degree of Science, major in Computer Science at Department of Mathematics and Computer Science, Faculty of Science, Chulalongkorn University. On January 2016, she was invited for oral presentation about Business Process Improvement using Adjustable Parameters on Simulation: A Case Study in Restaurant Business in the 5th International Conference on Intelligent Computing and Applications, Brisbane, Australia.