

Application of Dynamic Programming to Sweet Delights: A Market Research for Online Baked Products

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Abstract

People nowadays are more engaged in supporting small enterprises during the pandemic. One of the businesses that arise are baked products, clothing line, accessories, and other items that are useful in the present situation. Big enterprises started from small enterprises that maintained their growth by identifying the important factors to consider when growing a business. Many business owners are aware of their current progress which paves the way for more opportunities and insights as they handle their business. This paper will determine what will be the maximization profit that the owner will get with the best optimal solution that we have gathered. This study will be conducting a direct interview to the owner for them to gather the data that the owner has and use it to conduct a survey to determine what preferences, trends, and the most profitable product that the people will like about. The products, product mix, constraints, preferences that were used for the LP model that would help improve market strategy and product optimization. The results determined the prioritization of Sweet Delights which should mainly focus on producing cheese rolls or one product alone. The study suggests increasing production hours to determine the most preferable in the menu and to maximize the profit.

Keywords:

Pandemic, Small Business, LP model, Profit Maximization, Optimal Solution

1. Introduction

People nowadays are more engaged in supporting small enterprises during the pandemic. One of the businesses that arise are baked products, clothing line, accessories, and other items that are useful in the present situation. Big enterprises started from small enterprises that maintained their growth by identifying the important factors to consider when growing a business. Many business owners are aware of their current progress which paves the way for more opportunities and insights as they handle their business. Micro, small business enterprises (MSMEs) sector is considered as one of the major economic growth drivers in the Philippines at any rate of development. As shown in the most recent survey of the Department of Trade and Industry, MSMEs contribute almost 64.97% of the total jobs generated by all types of business establishments in all sectors and which also accounts for almost 99.6% of total registered enterprises. In developing countries, micro and small enterprises (MSEs) comprise the largest part of the industrial fabric and are among the most important development agents in society. MSEs offer many millions of poor people around the world the possibility of earning money, training, work experience and employment. However, empirical evidence shows that most small enterprises never develop the business beyond a certain scale and only a small minority of them manages to upgrade to the next level of productivity, income, and employment.

On the other hand, quantitative criteria include the number of staff that works in the firm, the annual wages and salaries expenses, total annual revenue that the business produce, the value of the assets of the business which involve their materials, equipment's, properties and the like, and the share of ownership that is held by the owner-manager.

Sweet Delights is a small baked products are one of the most trending and popular because, the common products of bakery are Cheese Roll, Ube Roll, Ube Cheese Pandesal, Cheesy Ensaymada, Sausage Roll Ham, and Cheese Pandesal are the most trending snacks for customers especially during this pandemic it's also study will help to know the marketing aspect of the business.

1.1 Objectives

In this study, the researchers would conduct several optimal solutions which can determine what product mix will be more profitable than the other product mixes in this study. In addition, the researchers will determine what optimal quantity that the seller can produce for them to know what the profit is they can earn based on their sales level. If data is not available, the researchers can conduct a survey in which will determine the optimal preference of the consumers that will help the business grow as they will receive knowledge on what they can put in their product mix.

2. Literature Review

Mandviwalla and Flanagan (2021) stated that digital transition of businesses contributed to the survival and life of a business since the crisis caused by the pandemic had occurred. The study covers the different factors affecting the condition and stability of enterprise to digitalize small businesses. The findings of the study of small business indicated the importance of engagement, selling, and delivery through technology that would affect the process. In a recent study conducted in Malaysia, one of the most affected are the small enterprises by the current movement in the industry (Fabiell et. al, 2020)

During the pandemic, many enterprises experienced downfall by losing their employees, new market trends, competition, lack of consumers, etc. This type of difficulties many industries had experienced emphasized the importance of sales and in terms of maximization of their profit. According to Soriano (2017), the owners of small to medium enterprises are being referred to as the drivers of economic growth. It plays a major role in terms of expanding the competition among emerging sectors. Another role of small businesses is its ability to provide a new approach in economic and social development where its impact and contributions are seen with great potential by providing different ideas. On the other hand, Pedersen and Ritter (2020), stated that it is necessary to understand the enterprise's condition to make strategic decisions. In addition, cooperation and competition are expected to affect the overall performance of a business and implementation of these strategies to large enterprises are still uncertain (Crick & Crick, 2020).

Small businesses' maintenance could be handy in some situations. An example would be the Covid19 pandemic where it resulted in different adjustments and provided difficulties to business owners. Some owners experienced difficulties in many aspects of their business while some made their business more profitable despite the pandemic. According to Sharma et. al (2020), it is difficult for owners to manage their business since certain types of uncertainty emerged and different kinds of strategies are explored to deal with these challenges effectively. This type of difficulty many business owners have encountered plays a major role in providing insights about decision making and specific improvements. It allows sellers to generate a unique way to sell their products and attract more buyers despite the pandemic. The pandemic also emphasized the importance of the choice of products based on the consumer's preference in terms of variety, quality, cost, and demand. It is important to identify the trends in the market to evaluate the current progress of your business and come up with a solution to increase sales and optimize products.

Today, customer feedback plays a major role in business by providing their statements that can be used to further suggest and satisfy the room for improvement. Communicating with the customers are essential in maintaining the business, especially for small enterprises which emphasize the factors to be considered to attract buyers and potential adjustments for the business. The feedback contains information that consists of suggestions that would help maintain the business such as the factors to consider when buying a product (packaging, delivery, taste). Another type of method to continuously improve a food business is by forming strategies to cater the consumer's demands. One way to improve the quality is by product optimization. The process itself defines the method of undergoing certain changes or adjustments for improvement or technically, to make the product more attractive or maintain its consumers.

In a study by Moonga (2019), it defines the importance of product optimization of traditional fermented milk. The study focuses on the product's components and to optimize its production process. The research assessed the different local production processes, important production parameters, function, and microbial community composition. It indicated that the milk's composition was affected by different factors such as geographical location, the method of

production, the type of producer, fermentation container, pH level, and fermentation time. The study emphasized the impact of external factors which affect the quality of a single product. The quality is an important aspect of a product since it would remind the consumers of their overall satisfaction within the product and would promote a positive, significant effect on the performance and status of the business.

In the baking industry, the people's interest in a specific product during the pandemic or crisis defines the important characteristics within a population or consumers. It is necessary to identify the influencing factors of the bakery products consumption and its importance given to the product in the media amidst the pandemic (Ladaru et. al, 2021), In addition, the media affects the consumer's perception on advertising the products by its quality, service, etc. Some industries have taken the leap to focus on boosting their media presence and adding varieties to increase sales that are appropriate in the middle of a crisis. Numerous businesses represent the idea of adjustment on the consumer's preference such as making a new flavor, recipe, packaging, or promos.

Amiens and Adedoyin (2020) stated the utilization of dynamic programming is evaluated based on its decision-making capabilities in small to medium sized businesses. The study focused on perceiving the effects on the application of dynamic programming to various forms of enterprises by using interviews, direct observation, and collecting records that would contribute to the study. The results indicated an occurrence of a maximum profit based on the production of the bread and given constraints such as entire production capacity and demand. The study conducted suggests that the use of dynamic programming should be practiced in terms of decision-making.

On the other hand, the study conducted by Diniz (2020) suggests that to maintain the consistency on strategic plans and equipment replacement decisions, it is necessary to develop a dynamic programming algorithm that identifies the specific composition of the replacement problem. The output produced will be used to identify the project needs, operational, and harvesting costs. In addition, Linear programming is also used in decision making by entrepreneurs. The method is used for drawing an optimization technique for maximizing profit with the available resources (Olayinka et. al, 2015). It can also be applied to business analytics when taking big data into consideration that a large-scale LP formulation is required (Chung, 2015).

Linear Programming and Dynamic Programming are both significant in product mix optimization for small to large scale business. Molina (2018), added that owners that are unfamiliar with the business industry tend to rely on a trial and error process in managing their finances especially when buying products from suppliers. The clothing store's data were used to determine the parameters for the Linear Programming formulation. The LP model used the QM software to come up with the most profitable product mix to be purchased from their supplier and provide an optimal solution. Another application of linear programming for optimizing the product mix is also used in the apparel industry. It emphasized the importance of meeting the consumers needs, determining image, focusing on the business condition, and keeping track of inventory on optimizing product mix (Woubante, 2017). The two algorithms are both used for optimization but with a different approach. LP is more suitable for solving linear optimization problems, while the DP determines the optimal solution (Skugor & Deur, 2018).

3. Methods

This chapter aims to discuss the different methodologies that the researchers used for gathering the data and analysis, since it is critical for the research paper. The methodologies will consist of conceptual framework, data gathering procedure and analysis or evaluation procedure. In this segment of the paper, the conceptual framework will describe and show the overview of how the data is achieved in the paper. The processes that the researchers used as shown in the figure below is how the researchers were able to acquire its data

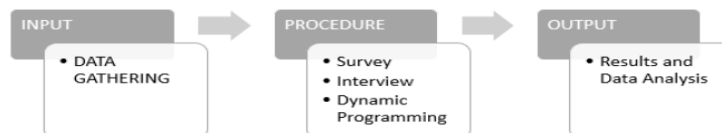


Figure 1

4. Data Collection

The researchers will conduct the procedure by applying the dynamic programming based on what the researchers have gathered from the data from the survey and interview that was made far ahead of time. The researchers will analyze what they can get from the preferences, trends, and the most profitable product that the people have answered based on the survey provided to them. With completing the newest data from analyzing the survey that the researchers made, the researchers will try to solve what is the best optimal solution that the researcher can get by trying to maximize profit of the business or rather get the increase of sales of the business. If the solved data can't help the business, the researchers will help the business by providing what is the best optimal marketing strategy that the owner could do.

5. Results and Discussion

5.1 Numerical Results

Table 1. Production Table

	Product Type			
	Cheese Roll	Ube Roll	Ube Cheese Pandesal	Cheesy Ensaymada
Cost per unit	\$10	\$28	\$25	\$30
Total cost per box	\$250	\$280	\$250	\$180
Demand (per pcs.)	11	7	16	6
Supply	150			

DECISION VARIABLES

X1= number of cheese roll (per pc.) available to produce every other day
 X2 = number of ube roll (per pc.) available to produce every other day
 X3 = number of ube cheese pandesal (per pc.) available to produce every other day
 X4 = number of cheesy ensaymada (per pc.) available to produce every other day
 MAXIMIZE $Z = 250X1 + 280X2 + 250X3 + 180X4$
 s.t.

$$\begin{aligned} X1 &\leq 11 \\ X2 &\leq 7 \\ X3 &\leq 16 \\ X4 &\leq 6 \\ 10X1 + 28X2 + 25X3 + 30X4 &\leq 150 \\ X1, X2, X3, X4 &\geq 0 \end{aligned}$$

Based on the data gathered, 40 respondents were specifically asked on how often do they purchased baked products. Result shows that the highest percentage is 37.7%, a total of 13 respondents, answered that they purchase baked products on a weekly basis. Then, 12 respondents answered that they purchased baked products monthly, 8 of them purchased baked products once a month, and finally, 7 respondents bought their products on a daily basis. Since the objective of this study is to maximize the business profit given a week, and the operating hours of the business is every other day. The researchers had considered the 7 respondents that answered daily.

5.2 Graphical Results

As seen on Table 1, the researchers analyzed the results and came up with the decision variables together with their following constraints (Figure 3). Based from the table below, the four products that are highly in demand are: Cheese Roll, Ube Roll, Ube Cheese Pandesal, and Cheesy Ensaymada. The researchers were able to come up with the following variables after conducting the interview. It shows that the highest demand of product is the Ube Cheese Pandesal which has a total of 16 demands per pieces. Since the objective of the study is to maximize the profit in a week, for the four products and the operating hours for the business is every other day (Sunday, Tuesday, Thursday, Saturday). Given that the four products are all different, the demand for each product will be highlighted. For each product, given a unit of pieces, 150 of supply is only available for a week, according to the business owner. The following table presents the estimated increase in demands (in pieces) for the different types of product mix. From Table 1, the researchers were able to form a linear programming model based on the production table (Figure 3). The decision variables given were all the product mix available. The variables were assigned as X1, X2, X3, and X4 as the decision variables. The objective function will be to maximize the profit, and the constrains will be the demand of

each product, the cost per unit of each product and the availability or supply of the business given a week of time. This study seeks to apply dynamic programming to the small businesses such as sweet delights. To solve, the researchers initially formed a Linear Programming Model, from there, it can be transformed or solve by dynamic programming formulation.

Figure 2. Linear Programming Formulation

ELEMENTS	
Stage:	number of days i in a week (every other day)
State:	available product mix at the beginning of the stage
Alternative:	number of product mix to be produce for each stage

Figure 3. Elements

STAGE 4:		Optimal values	
$f_4 = \max_{0 \leq x_4 \leq b_4} = \max \{180x_4\}$		b_1	11
		b_2	7
		b_3	16
		b_4	6
$f_4(b_4) = \max \{180x_4\}$			
where:	$x_4 \leq b_4$	=	$x_4 \leq 6$
	$30x_4 \leq 150$	=	$x_4 \leq 150/30 = 5$
$f_4^*(b_4) = \max \{180x_4\}$			
$x_4 = 180 \{ \min (6 - x_3, 150/30 - 25/30x_3 - 28/30x_2 - 10/30x_1) \}$			
State	Opt sol		b_4^*
	$f_4(x_4)$		
x_4	$180 \{ \min (6 - x_3, 150/30 - 25/30x_3 - 28/30x_2 - 10/30x_1) \}$		5

Figure 4. Stage 4

STAGE 3:		Optimal values	
$f_3 = \max_{0 \leq x_3 \leq b_3} = \max \{250x_3\}$			
$f_3^*(b_3) = \max \{250x_3\}$			
$f_3^*(b_3) = \max \{250x_3 + f_4^*(6 - x_3, 150/30 - 25/30x_3 - 28/30x_2 - 10/30x_1)\}$			
where:	$x_3 \leq b_3$	=	$x_3 \leq 16$
	$25x_3 \leq 150$	=	$x_3 \leq 150/25 = 6$
$f_3^*(b_3) = \max \{250x_3 + 180 \min(6 - x_3, 150/30 - 25/30x_3 - 28/30x_2 - 10/30x_1)\}$			
$f_3^*(b_3) = \max \{250(3) + 180 \min(6 - (3), 150/30 - 25/30(3) - 28/30x_2 - 10/30x_1)\}$			
$f_3^*(b_3) = \max \{750 + 180 \min(6 - (3), 150/30 - 75/30 - 28/30x_2 - 10/30x_1)\}$			
$x_3 = 750 \{ \min (3, 150/30 - 75/30 - 28/30x_2 - 10/30x_1) \}$			
State	Opt sol		b_3^*
	$f_4(x_4)$		
x_3	$750 \{ \min (3, 150/30 - 75/30 - 28/30x_2 - 10/30x_1) \}$		6

Figure 5. Stage 3

STAGE 2:		
$f_2 = \max_{0 \leq x_2 \leq b_2} = \max \{280x_2\}$		
$f_2^*(b_2) = \max \{280x_2\}$		
$f_2^*(b_2) = \max \{280x_2 + f_3^* + f_4^*(3, 150/30 - 75/30 - 28/30x_2 - 10/30x_1)\}$		
$f_2^*(b_2) = \max \{280x_2 + 750 + 180(3, 150/30 - 75/30 - 28/30x_2 - 10/30x_1)\}$		
where:	$x_2 \leq b_2$	= $x_2 \leq 16$
	$28x_2 \leq 150$	= $x_2 \leq 150/28$
$f_2^*(b_2) = \max \{280x_2 + 750 + 180 \min(6 - x_2, 150/30 - 75/30 - 28/30x_2 - 10/30x_1)\}$		
$f_2^*(b_2) = \max \{280(150/28) + 750 + 180 \min(3, 150/30 - 75/30 - 28/30(150/28) - 10/30x_1)\}$		
$f_2^*(b_2) = \max \{1500 + 750 + 180 \min(3, 150/30 - 75/30 - 5 - 10/30x_1)\}$		
$x_2 = 1500 + 750 \{180 \min(3, 150/30 - 75/30 - 5 - 10/30x_1)\}$		
State	Opt sol	
	$f_2(x_2)$	b_2^*
x_2	$1500 + 750 \{180 \min(3, 150/30 - 75/30 - 5 - 10/30x_1)\}$	150/28

Figure 6. Stage 2

STAGE 1:		
$f_1 = \max_{0 \leq x_1 \leq b_1} = \max \{250x_1\}$		
$f_1^*(b_1) = \max \{250x_1\}$		
$f_1^*(b_1) = \max \{250x_1 + f_2^* + f_3^* + f_4^*(3, 150/30 - 75/30 - 28/30x_2 - 10/30x_1)\}$		
$f_1^*(b_1) = \max \{250x_1 + 1500 + 750 + 180(3, 150/30 - 75/30 - 28/30x_2 - 10/30x_1)\}$		
where:	$x_1 \leq b_1$	= $x_1 \leq 11$
	$10x_1 \leq 150$	= $x_1 \leq 150/10 = 15$
$f_1^*(b_1) = \max \{250x_1 + 1500 + 750 + 180 \min(6 - x_2, 150/30 - 75/30 - 28/30x_2 - 10/30x_1)\}$		
$f_1^*(b_1) = \max \{250(11) + 1500 + 750 + 180 \min(3, 150/30 - 75/30 - 5) - 10/30(11)\}$		
$f_1^*(b_1) = \max \{2750 + 1500 + 750 + 180 \min(3, 150/30 - 75/30 - 5) - 10/30(11)\}$		
$x_1 = 2750 + 1500 + 750 \{180 \min(3, 150/30 - 75/30 - 5 - 11/3)\}$		
$x_1 = 2750 + 1500 + 750 + \{180 \{ (3, -6.17) \}$	State	Opt sol
$x_1 = 2750 + 1500 + 750 + \{180 (-6.17)\}$		$f_2(x_2)$
$x_1 = 2750 + 1500 + 750 + \{-1100.6\}$	x_1	$2750 + 1500 + 750 \{180 \min(3, 150/30 - 75/30 - 5 - 11/3)\}$
$x_1 = 5000 + \{-1100.6\}$		b_1^*
$x_1 = 3889.4$		11

Figure 7. Stage 1

Optimal Policy	
Quantity to Produce	
X1	11
X2	150/28
X3	6
X4	5

Figure 8. Optimal Policy

As seen on Figure 3, given the elements of the dynamic programming formulation, which are the following: stage, states, and alternatives. For this study, the stage will be the number of days in a week, which is the operating hours of the business (every other day). The state as the available product mix at the beginning of the stage, and the alternatives as the number of product mix to be produce for each stage. To solve the problem with the use of dynamic programming, the research used the backward recursion method, meaning that the problem will be solved from the last stage to the first stage. Starting from stage 4 (Figure 4), the researchers first determine the optimal value which

are the following constraints, thus, the cost per unit for each product. Then, the researchers must determine the feasible value of X4, the maximum value of X4 will be the non-negative constraints. Given the condition that we now have the optimal values. It is now possible to solve for the optimal solution for X4, and optimal value as well. Then, with the optimal solution for stage 4, we proceed in determining the optimal solution and optimal value for Stage 3. As seen on Figure 5, by maximizing the optimal solution for stage 3, we take the value from the objective function and solve it accordingly. In solving, the researchers performed a direct substitution of the optimal values to find the optimal solution for stage 3. The same procedure was done by the proceeding stage until stage 1, which is the final stage (Figure 7).

5.3 Proposed Improvements

The researchers think that the best option for the small baking business is to focus more on their best-selling product. Results shows that the ube roll and ube cheese pandesal are products that are high in demand compared to the other products. Moreover, the researchers also suggests to promote the other product that are low in demand. The business should add more products so that customers will have more choices in selecting which product they should buy.

5.4 Validation

Solution	0	1	0	0	MAX Z			280
Decision Variables	Cheese Roll	Ube Roll	Ube Cheese Pandesal	Cheese Ensaymada	COEFFICIENTS			
Objective Function	X1	X2	X3	X4	LHS		RHS	
	250	280	250	180				
CONSTRAINTS:								
<i>DEMAND</i>								
Cheese Roll	1	1	1	1	1	≤	11	
Ube Roll	1	1	1	1	1	≤	7	
Ube Cheese Pandesal	1	1	1	1	1	≤	16	
Cheese Ensaymada	1	1	1	1	1	≤	6	
<i>SUPPLY</i>								
Availability of each products	150	150	150	150	150	≤	150	

Figure 9. LP Formulation with Solver

Variable Cells

Cell	Name	Final Value	Reduced Cost	Objective Coefficient	Allowable Increase	Allowable Decrease
\$C\$23	Solution	0	-30	250	30	1E+30
\$D\$23	Solution	1	0	280	1E+30	30
\$E\$23	Solution	0	-30	250	30	1E+30
\$F\$23	Solution	0	-100	180	100	1E+30

Constraints

Cell	Name	Final Value	Shadow Price	Constraint R.H. Side	Allowable Increase	Allowable Decrease
\$G\$29	Cheese Roll LHS	1	0	11	1E+30	10
\$G\$30	Ube Roll LHS	1	0	7	1E+30	6
\$G\$31	Ube Cheese Pandesal LHS	1	0	16	1E+30	15
\$G\$32	Cheese Ensaymada LHS	1	0	6	1E+30	5
\$G\$34	Availability of each products LHS	150	1.866666667	150	750	150

Figure 10. Sensitivity Report

To compare, the researchers also solved the problem using Excel Solver (Figure 9) given the Linear Programming Model that was formulated in solving the study (Figure 2). Figure 10 also shows a sensitivity report for each product given the Linear Programming Formulation of the problem.

6. Conclusion

People nowadays are more engaged in supporting small enterprises during the pandemic. One of the businesses that arise are baked products, clothing line, accessories, and other items that are useful in the present situation. Big enterprises started from small enterprises that maintained their growth by identifying the important factors to consider when growing a business. This used the applications of LP model and Dynamic Programming in finding the optimal solution for the Sweet Delights Dessert Shop only. The data gathered are mainly based on the cost of the products, product mix, constraints, preferences that were used for the LP model that would help improve market strategy and

product optimization. In addition, the results determined the prioritization of Sweet Delights which should mainly focus on producing cheese rolls or one product alone. The study suggests increasing production hours to determine the most preferable in the menu and to maximize the profit.

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Biography

James Brylle C. Foz, a second-year student in Mapua University. He was born on March 22, 2002 in Pasay City, and now lives in Las Pinas City. James took his primary education at Integrated Montessori Center and took his secondary education at Saint Francis of Assisi College. During his primary and secondary education, he achieved a lot of academic excellence awards and has won a lot of cooking competitions for his co-curricular activities. While in Senior High School, he took STEM for his academic strand, and now currently pursuing his course of Bachelor of Science Major in Industrial Engineering at Mapua University, he joined his first organization at PIIE and currently he is a member of it.

Martin James Del Rosario Olan was born on October 28, 2000 in Malolos, Bulacan. He was raised in Manila and the youngest of their family. Martin took his primary education in Christian Academy of Manila where he graduated as Salutatorian of his class. For his secondary education, he went to Malayan High School of Science and engaged into extracurricular activities such as sports and became a member of the basketball varsity team of their school, Mapua Red Robins. In Senior High School, he took STEM strand in Mapua University Intramuros and graduated with honors last 2019. Currently, He is studying his 2nd year of Bachelor of Science in Industrial Engineering in Mapua University.

Daniel N. Perez, born and raised in the province of Paete, Laguna on the 20th of July, 2001. He grew up being the youngest of the family together with his two older brothers. On his educational background, he started his primary education at Little Shepherd Integrated Montessori in Lumban, Laguna. Then, on his secondary education, he migrated to Italy to continue his studies for five years. During those five years, he was able to fully understand the Italian language and to speak it fluently. After finishing his secondary education, he went back to the Philippines to continue on pursuing his studies. He went back to his primary school in Lumban for his Senior Year and took the General Academic Strand (GAS). He is now studying at Mapua University and is currently taking the course of Bachelor's of Science Major in Industrial Engineering.

Christian Jay Sesorio is a college student currently in MAPUA University. His major is Industrial Engineering and Management. He is also a member of an organization under MAPUA University, namely, Philippine Institute of Industrial Engineers (PIIE) - Mapua University Student Chapter in 2018.

Rene D. Estember is a Professor in the School of Industrial Engineering and Engineering Management at the Mapua University in Manila City, Philippines. He earned his B.S. in Management and Industrial Engineering from Mapua Institute of Technology, Master's in Business Administration from Ateneo de Manila University, Master of Science in Industrial Engineering from the University of the Philippines, and finishing his Doctorate in Business Administration from the Pamantasan ng Lungsod ng Maynila (PLM), all located in the Philippines. He is presently undertaking consultancy work on quality management systems documentation and also involved as a regular resource speaker of a training company conducting technical trainings. His research interests include human factor and ergonomics, manufacturing, risk management and optimization