

A COMPARATIVE STUDY ON THE ENGAGEMENT IN THAI LAW AND LAW OF THE LAO PEOPLE'S DEMOCRATIC REPUBLIC

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Abstract - An engagement is the legal relationship that men and women will marry in the future, and the man will hand over or deliver property as the dowry to the woman as the evidence of engagement. However, the law does not force the man and woman to make an engagement before; hence, the man and the woman can enter into the marriage without having the engagement. According to Thai Law, the engagement shall be made when the man and the woman who are expressing their intentions to enter into the engagement contract is seventeen years of age or above. If the engagement condition is violated, it is void. In the case of minors entering in the engagement, they shall be first consented by the father and mother, guardian, or parents, as the case may be. The engagement will be voidable if it is performed without consent, and this is different from the law of Lao People's Democratic Republic as it does not determine the age of a man and a woman who are entering into the engagement, and the engagement can arise from the agreement between fathers and mothers, matchmaker of a man, and a matchmaker of a woman according to the intention of both man and woman to live together as husband and wife in the future, but they cannot marry because the marriage conditions are not fulfilled. The law determined that memorandum according to the tradition must be made. With this reason, according to the law of the Lao People's Democratic Republic, the engagement can take place even men and women are under the age of seventeen.

Keywords - Engagement, Engagement Gift, Law

I. INTRODUCTION

In most societies, formal marriage begins at the time of marriage which created the legal relation in legal field. The Family Law in Thailand stated that the marriage begins when there is a marriage registration by law, and it creates the status and relationship between husband and wife as spouses. Upon the marriage, the relationships between man and woman before the marriage may arise in the form of engagement. In the past, Thai society was more focused on traditional engagement with the consent of parents and relatives. The principle has been developed to become a rule as a legal condition appeared in Lanna Law and legal nature of spouses until it is presented nowadays in the Civil and Commercial Code, Book 5: Family Law [1].

The engagement or the making of engagement contract is a legal relationship between a man and a woman who promises to marry and live together as husband and wife [1]. The man reserves the woman for marriage by law. Therefore, the engagement contract is the contract occurred before the marriage. However, even though engagement is inherited from the past until the family law supported it in the form of a contract in Book 5, the foreign law such as French law and English law do not support the engagement to have binding effect as a contract, but it is only an agreement condition made by a man and a woman before marriage [2].

The property is provided as a guarantee for the fulfillment of the contract to the fiancée called "arra", which developed from the custom of the East. If

either party fails to comply with the contract, the other party shall be entitled to claim for the compensation from breaching the contract. In the legal nature of spouses in the past, parents had independent power over their children; therefore, the engagement is operated by parents without having to ask for the children's consent. An engagement occurred when a man brought a tray of gifts to engage the woman, starting from Khan MakKlaoTham (tray of asking) to ask for the will of engagement. If a woman accepted the tray of gifts as an engagement, the engagement contract was made with the promise to marry with the man. If the woman denied, the asking is cancelled, and the tray of gifts will not be brought to the woman. It is different from the current law that the validity of an engagement occurs when a man delivers or transfers as property of engagement to a woman to prove that he will marry with the woman. Hence, the engagement must come from the consent of both man and women, but not the compulsory that the man and woman must enter into the engagement before marriage. Thus, men and women may marry without the need for engagement. On the other hand, if there is a will to be bound as a fiancée, the engagement must be subjected to the legal enforcement [3].

According to Thai law, there are several conditions of engagement, such as the minimum age for a man and a woman to make an engagement at the age of seventeen pursuant to Section 1432, and in the case of minors entering in the engagement shall be first consented by the father and mother, guardian, or parents pursuant to Section 1436; whereas, the validity of the engagement is occurred when the man

delivered or transferred the engagement property to the woman pursuant to Section 1437. On the other hand, if the engagement contract is breached, another party entitles to claim for the compensation. However, the engagement contract has a special quality that it cannot force the man and the woman to comply with the contract by marriage pursuant to Section 1438. Thus, it is contrary to the consent of the marriage [4-5]. Whereas the law of the Lao People's Democratic Republic, the neighboring country that has similar cultures and traditions to Thailand and are one of the members of the Association of Southeast Asian Nations (ASEAN) or the ASEAN Community. There is a provision related to the relationship between a man and a woman subjected to the engagement in Chapter 1: the engagement and the asking for marriage proposal stated that if the couple want to get married as a husband and a wife, but the conditions for the marriage is incomplete at that time, both parties who wish to marry shall make the memorandum about the engagement according to the tradition [6-7]. The man can, whether or not, deliver property or precious object to the woman, and the contract parties are called as "the couple." It is different from Thai law. In addition, it has the distinctively different on the engagement provision. The study on the conditions related to the engagement under the laws of both countries is interesting. Thus, it is for the accurate understanding for the law enforcement which will be beneficial for protecting the rights and promoting the quality of life of people in society [8].

II. DETAILS EXPERIMENTAL

2.1. METHODOLOGY

A. Objective of the research

To study and compare the conditions of engagement under Thai law and the law of Lao People's Democratic Republic.

B. Research Methodology

The Comparative Study on the Engagement in Thai Law and Law of the Lao People's Democratic Republic is conducted to find the appropriate legal measures to apply by using Qualitative Research, and the Documentary Research is conducted by studying and compiling relevant documents as well as in-depth interviews.

C. Expected benefits

For the benefits towards the law education industry and to guide the improvement and development of family law in relation to engagement in order to lead to the development of quality of life in the ASEAN region in the future.

D. Literature Review

The nature and conditions of engagement. The engagement is performed to allow a man and a

woman to learn each other and get to know each other. In society, it is good that a man and a woman can get to know each other and go somewhere else without being seen as inappropriate action.

1. The engagement under Thai Law

Thai law specifies the conditions of engagement into 3 factors, which are

1.1 Condition of age for a man and a woman who are entering into the engagement

For the engagement condition, it can be fulfilled only when a man and a woman are seventeen years of age, according to Section 1435, which has been used since 1976. When there was an amendment on the family law, the engagement, the engagement conducted while a person is not yet seventeen years of age is void. It means, there is no effect since in the beginning. Therefore, the man and the woman are not the betrothed. The condition of age is no the ability to perform the juristic act, but it is the qualification of performing the juristic act, and it is the essence of the validity of the juristic act.

1.1 Conditions related to the consent in the case that the minor is entering into the engagement

The engagement is one of the juristic acts; hence, the man and the woman must express their intentions to enter into the engagement by themselves. However, in the case that the man and the woman reached seventeen years of age, but not yet reaching the legal age would like to enter into the engagement under Section 1436, it is stated that it must be consented by the following persons:

- (1) Father and mother as persons using parental power together;
- (2) Father or mother in the case that mother or father is dead or has been deprived from the parental power or is not in a condition or position that may give consent, or in such circumstances, the minors cannot ask for the consent from the mother or the father, so it is only possible for one person to give consent;
- (3) The adopter, in this case, is foster parents. Thus, due to the registration of adoption, the father and mother will naturally be terminated from having parental power to the minors; therefore, the parental power belongs to the foster parents since then;
- (4) Parents, in the case of no father and mother, no foster parents, or have but such person is deprived from the parental power. In this case, the parents from the order of the court act as a person giving consent for the engagement of a minor.

1.2 Conditions related to the validity of the engagement. Dowry is the property that the man has handed or transferred to the woman at the time of engagement as evidence that he will marry her under Section 1437. If the man only agreed to deliver the property, but it is not delivered at that time, such agreement is not the agreement of the engagement. Thus, the engagement requires the delivery of dowry to the woman in every case. After performing the engagement, the woman will have the right on the dowry, and it can be a property includes things as

well as incorporeal objects, susceptible of having a value and of being appropriated.

2. The engagement under the law of Lao People's Democratic Republic.

The law of the Lao People's Democratic Republic gives the meaning of the word "engagement" as the agreement between the parents, a matchmaker of a woman, and a matchmaker of a man who wish to live together as husband and wife in the future by making memorandum between the man or the woman, or giving money or precious objects to the woman. When a man and a woman who wish to live together as spouses, but they are not able to comply with the marriage contract at that time, both man and woman shall make a memorandum about the engagement according to the tradition. In this case, the man will, whether or not, provide property or precious objects to the woman. However, such engagement will be arranged for the marriage in the future. Therefore, if a man and woman meet the conditions of marriage in the future, the man will accompany his parents to propose the woman for the marriage according to the tradition again in order to negotiate about the bride-price or dowry under Thai law as well as a preparation for the marriage ceremony.

Nonetheless, in the case that the engaged couple had intercourse before the marriage, and then the man refuses to marry the woman as his wife, the man shall pay for the compensation to the woman and her family according to the tradition. If such intercourse leads to the pregnancy, the man must be responsible to raise the child until he or she reaches the legal age of eighteen, including any other necessary expenses.

III. RESULTS

The engagement by law in Thai family requires gender and minimum age for persons entering into the engagement clearly that it can be made when a man and a woman are seventeen years of age as specified in Section 1435 as same as in the case of marriage, but if there is a reasonable case, the court may permit to enter into marriage before having seventeen years of age, but if it is the marriage that breaches the condition of age, the marriage will be voidable. Section 1504 is different from the engagement that breaches the condition subjected having the age under seventeen years old which the result is void and has no effect since in the beginning. While in the law of the Lao People's Democratic Republic, if it is considered from the intent of the words in the law, it can be seen that the reason for the engagement occurred because both man and woman want to live together as husband and wife, but the marriage conditions cannot be followed as, for instances, the age is not eighteen years old; therefore, Section 9 of the law allows for the engagement, and the minimum age of the engaged couple is not specified for the persons entering to the engagement,

unlike the marriage. In this case, the father and mother are persons who consider for the appropriate in terms of age according to the traditional practices.

Next, according to Thai law, the engagement occurred by the agreement between a man and a woman, so a man and woman are willing to make an engagement contract by themselves without the consent from their parents, except in the case of the engagement between minors with the age of seventeen, but not yet twenty years of age as they have to be screened by fathers and mothers, adoptive parents or guardians as the controller of the minor's legal capability to act; whereas, in the law of the Lao People's Democratic Republic Engagement, the engagement starts with an agreement between parents and a matchmaker from the woman's side and the parents and a matchmaker from the man's side who will come for negotiation as an initial agreement, and the man, whether or not, will give property or precious objects to the woman, but according to the traditional practices, the man is likely to give money and property to the woman.

Nonetheless, the validity of the engagement under Thai law will occur when the man delivers or transfers the property of the engagement to the woman at the time of engagement in order to prove that he will marry the woman. Section 1437 has no provision to enforce that the engagement shall be in writing which is different to the Section 1/3 of the law of the Lao People's Democratic Republic that a man and a woman shall record the engagement in the presence of the villager as evidence of engagement according to the traditions.

DISCUSSION AND CONCLUSIONS

The result of the comparative study on the engagement in Thai Law and Law of the Lao People's Democratic Republic can be seen that laws of both countries are from the basic of cultural and social norms within each country. With this reason, the engagement conditions are based on the beliefs inherited from the tradition of the family. It is appropriate to fit the lifestyle. Even the age of the person who can make engagement of the two countries is different, both countries have legal and social measures to protect men and women who intent to live together as husband and wife in the future. For the law of the Lao People's Democratic Republic, it provides parents the right to participate in making an agreement for the engagement according to the traditions, which is similar to the legal nature of spouses of Thailand in the past that the parents had independent power over their children; whereas, the current Thai law provides the independent right to men and women who meet legal ages to perform the engagement with their intentions and wills under the scope of morality according to the natural rules, and parents will only be those who screen for the appropriateness by providing consent to the

engagement between the minors. The government and society can protect and certify the engagement as the beginning of family formation, which is a natural and fundamental social element in every case whether the conditions of the validity of engagement will specify to deliver or transfer property as an engagement gift to the woman while making an engagement or specify to record the engagement as evidence. Thus, it is in accordance with the context of change in each society.

SUGGESTIONS

There should be a study about the engagement, and the claims for compensation due to the engagement under the law of other countries. Thus, it is for the comparison on the similarities and differences with Thai law, particularly for the Association of South East Asian Nations (ASEAN) Member States for the further law development.

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GUIDELINES FOR THE FOREIGN WORKERS SUPPORT IN THE ASEAN COMMUNITY OF THAILAND

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Abstract - This research aim to study the policies related to the foreign workers support in the ASEAN Community of Thailand and to study the impact of measures to support foreign workers in the ASEAN Community of Thailand and to present guidelines for supporting foreign workers in the ASEAN Community of Thailand. Currently, the foreign workers management is still a problem even though Thai government is finding ways to solve the problem, the foreign workers are chosen to illegal way. Thus, it may be due to the fact that the cost of obtaining a work permit is quite high and it must be applied continuously. The most common problems, whether the registration and the application for work permit, the work of migrants is not covered and does not reach migrant workers, the proof of nationality of migrant workers is not accessible to them, and it is costly, or the registration and verification of citizenship is not covered and not reached. Moreover, there are many restrictions, and there is illegal child labor. Additionally, there is an unreachable and unsuitable universal education policy for a child of migrant workers, illegal immigrant labor movements who are taking this opportunity for their benefits, received the assistance from the government officers, and the protection system is not covered to all issues. These are problems waiting for solution and good guideline to correct these issues in the right way.

Keywords - Foreign worker, Asean community

I. INTRODUCTION

Thailand is a member state of Association of South East Nations (ASEAN). First, ASEAN has emerged under a security cooperation agreement in the Cold War because at that time, the world is divided into two parts: the free world, led by the United States, and the communist countries led by the Soviet Union. There are most of the countries in Southeast Asia are in free world, except Vietnam which is on the same side with the Soviet Union. During this time, both sides competed in the accumulation of weapon, space technology, economic espionage, and warfare through the Proxy War. At that time, Vietnam was considered a serious threat in Southeast Asia under the Domino theory, which was occurred from the expansion of communism and communist system in Asian. When China, North Korea, and North Vietnam became Communist, it is believed that other countries such as Laos, Cambodia, Thailand, Malaysia, etc. will be dominated by the communist system in the end as well. The fall of domino means the fall of democracy. After the Vietnam War ended, US Army was withdrawn; hence, the North Vietnamese Communist Party had announced the victory and it was likely to dominate all states in Southeast Asia. Numbers of countries such as Indonesia, Malaysia, the Philippines, Singapore and Thailand have been trying to revive the international organization in Asia under the Association of South East Nations (ASEAN), and there were 5 foreign ministries jointly signed the "Bangkok Declaration" with the coordination and assistance from the security as the main [1].

After the fall of the Soviet Union, it led to the end of the Cold War, and Vietnam where it was originally

supported by the Soviet Union was left alone, so it turned to United Nations Association of Southeast Asian Nations and requested to be a state member of ASEAN. After that, ASEAN had changed the objective to be the economic cooperation with the guideline to establish ASEAN Free Trade Area (AFTA), ASEAN Framework Agreement on Services (AFAS), ASEN Investment Area and the ASEN Community (AC) within 2015.

The ASEAN Charter is comprised of the ASEAN Political-Security Community (APSC), the ASEAN Economic Community (AEC) and the ASEAN Socio-Cultural Community (ASCC), which, as an ASEAN Community, will make more investment in cooperation and competition from state members. The ASEAN Community (AC) is also planning to negotiate the East Asian Free Trade Area (EAFTA) and the ASEAN Economic Partnership (CEPEA). Hence, it is necessary to have measures or actions to help Thai entrepreneurs to improve their competitiveness by improving the laws, rules, and regulations to facilitate business operations and developing the competitiveness of Thai private sectors. Thus, under the ASEAN Economic Community Blueprint (AEC Blueprint), the ASEAN Economic Community will be established fully within 2015 with the main purpose to lead ASEAN to be the joint market and production basement. Under such principle, ASEAN will have free movement in 5 branches, consisting of 1) goods, 2) services, 3) investments, 4) capitals, and particularly 5) skilled workers [2].

For Thailand, it is one of the major labor markets for jobseekers from ASEAN countries. At present, Thailand employs over one hundred thousand foreign

workers, including both legal foreign workers and illegal foreign workers that illegally entered into the Kingdom to work or escaped to the city. For the legal foreign workers, they are foreign workers entering into the Kingdom legally according to the alien immigration law by having visa and seal that permitted them to stay in the Kingdom temporarily, or permitted to enter to the Kingdom under the Investment Promotion Act or other laws, and the work permit is issued legally. Foreign workers in this type frequently worked in the careers that need knowledge and capability, or they will be skilled or semi-skilled workers, including the careers of management, engineers, technicians, specialists, etc., and are in need of the labor market in Thailand, or they are the workers delivered from parent companies abroad to work in the branch offices in Thailand [3]. These foreign workers are having the following nationalities: Japanese, British, Chinese, American, and Indian, etc. For the illegal foreign workers or those who escaped to work in the Kingdom are those who are entering in the Kingdom by violating the immigration law, and they illegally work by violating the Working of Alien Act, especially foreign workers from Myanmar, Laos, and Cambodia who escaped to work illegally in Thailand. At present, no one can tell the exact numbers of them.

The problem of illegal migrant workers is one of the major problems in Thailand that every government is aware of and tried to find the way to solve such problems. Thus, the problem of illegal migrant workers entering into the Kingdom is a major problem and it causes various effects to the country, whether the security problem, human trafficking problem, crime issues, and the problem that the citizens in the country are being violated in term of human rights.

Thailand has been experiencing a number of problems with several groups of escaping illegal migrants continuously, and it is likely to be more intense, respectively because of several factors, while the government's policies, strategies, measures, and guideline to solve problems of each government and organization are characterized according to each group of problem. As a result, the overall solution is lack of unity and efficiency, and it affects the stability of the national security and social order.

II. DETAILS EXPERIMENTAL

2.1. METHODOLOGY

A. Research Objective

Purpose of the study

1. To study the policies related to the foreign workers support in the ASEAN Community of Thailand.
2. To study the impact of measures to support foreign workers in the ASEAN Community of Thailand.

3. To present guidelines for supporting foreign workers in the ASEAN Community of Thailand.

B. Scope of the Study

This research determined the scope of the study for 2 factors which are

1. Government Policy Issues
2. Impacts

C. Research Methodology

This time, the research team collected variety of data formats through the study on the basic information from documents and collected data in the community by using the following steps:

1. Secondary data from the document for study and the Internet.

1.1 Study for information from documents containing community basic information, policy goals of the organization, and community justice related law.

1.2 Study for information from structure documents and missions of the organization

2. The primary data by collecting data from the community that the research team collected from the community.

2.1 For the interview obtained research team in the area, the study on the history of the community, and the change of community from the past to present, the team interviewed seniors and leaders in the community.

2.2 The in-depth interview on the thought belief, tradition, culture and community crime conflict management.

2.3 Observation divided into the observation without participation and participatory observation.

III. RESULTS AND DISCUSSION

Concept of Related Theory

Concept of History of Foreign Workers working as employees in Thailand. The civilization of the modern word causes the higher cost of living and the domestic civilization in the countries of foreign workers are inadequate to meet their demands; therefore, the foreigners migrate to work in more civilized countries due to the motivation to seek for the factors of living.

1.1 History of foreign workers who entered and worked in Thailand

In Thailand, there are foreign workers who live in a long time because Thailand has a political structure and economy that makes the foreign workers occupation and living freely. Certain types of foreign workers are living a long time, until they can transfer nationality as Thai's nationality subsequently. For Example Chinese people who plays an important role in Thai economic and trade scenes from the past to the present. Countries are very active, but they are reduced to a country that has a common trade, such as Holland, Portugal and some people just came into

contact with Thailand after 1845, the year that Thailand had made the Treaty of Blowing with England, and have influenced the economy in Thailand to the present such as United States of America, Sweden, Russia, Belgium, Italy, Australia, Hungary, Japan, and Taiwan. (Anderson, N., 2005, p. 9), etc.

1.2 For the principles of foreign workers employment, in Thailand, it has recently begun to accept foreign workers in the late 1980s and early 1990s as a result of the country's economic growth more than neighborhood countries. Most foreign workers come illegally. They come from Myanmar, South China, Laos, and Cambodia, and the Thai government used strict immigration policies as some migrant workers are harmful to the stability of the country, but labor force is lacked in fisheries and the construction work, so the employer put pressure on the government for the deregulation of law. As the result, many foreign workers came to work in Thailand. With such cause, the government must set a policy on migrant workers, especially the concept of transnational migration. The studies and researches by academic scholars and other organizations on the illegal migrant workers are as follows [4-5] :

The guide to motivate foreign workers to work in Thailand. The economic conditions in the country of the foreign workers are not conducive to work, resulting in insufficient income for their living, and there is poverty, starving, war, or administrative problems that cause insecurity in life and property. In addition, the country of labor is not well-regulated for the escaping out of the country, so it is easy to escape from the country. The attractiveness is that Thailand's economy has grown rapidly, and it causes the opportunity to work and earn money. This attracts labors from neighboring countries where there is less prosperous and has no easy way to earn money because government officials do not thorough supervision, and the government officials are labor brokers to employers in Thailand by themselves.

- Types of migrant workers in Thailand: There are two types of migrant workers who come to Thailand, who are legal migrants who legally entering into the Kingdom, and illegal migrants who escape to the kingdom.

- Legal migrant workers: There are four types of legal migrant workers as follows:

1. Lifetime type: this is the migrant workers who are allowed to work in accordance with the Announcement of the National Revolutionary Council No. 322, BE 2515 (1972), in accordance with Article 10 (1) of the Announcement. This permits lifelong work permits for migrant workers; unless, the migrant workers will change their careers. Although the Alien Act of 1978 is repealed, the Foreign

Workers Act, BE 2551 (2008) is effective, but this condition is still effective. Migrants who have been granted a lifetime work permit include: A migrant worker who is a resident of Thailand under immigration law and has worked before the effective date of the Announcement of the National Revolutionary Council No. 322 which is December 3, 1972, and had applied for an internal work permit. 90 days from the date of the effective date of the Announcement of the National Revolutionary Council No. 322 (which is within June 9, 1973). If the work permit is issued, but the migrant worker will not be granted a permit and still work until the date on which the Alien Work Act, 1978 was enforced (the Alien Work Act came into force on July 22, 1978), such migrant workers will be granted a lifetime employment permit, but no new career changes is allowed. The reason for working in Thailand of the foreign workers who applied and received the lifelong work permit due to the reason that these workers are migrant workers who reside in Thailand and work before December 13, 1972 (the date of the adoption of the Announcement of the National Revolutionary Council No. 322), and at that time, Thailand had no law requiring migrant workers to apply for work permit. Later on, Thailand enacted a law regulating the work of foreigners by applying for permission to work in accordance with the Announcement of the National Revolutionary Council No. 322 (the law enforced at that time). Therefore, the Announcement of the National Revolutionary Council No. 322 granted the authority to the Director-General of the Department of Labor to issue a permanent work permit to this migrant group. This type of migrant workers is recognized as legal migrants since then [6].

2. Temporary category is consisting of migrant workers who are permitted to enter into the kingdom temporarily (Non-immigrant visa). Temporary work permits are issued to migrant workers who are legal migrants under Immigration Act, entering in the kingdom by holding Non-immigrant visa, or the migrant workers who are having residence in Thailand and applied for the Work Permits for the migrant workers to receive Temporary work permits will be in accordance with the Working of Aliens Act, 2008 Section 9 which is prescribed that no alien shall engage in any work other than prescribed in the Ministerial regulations by taking into account the national security, the opportunities for Thai people to work, and the need of migrant workers who are necessary for the development of the country, and the permit shall be granted by the registrar, except for the alien who enters into the Kingdom temporarily under the law on immigration so as to engage in necessary and urgent work for a period of not exceeding fifteen days and that alien may engage in that work after giving written notification to the registrar. Such migrant worker who can apply for the permit under

Section 9 shall have residence in the Kingdom or have Non-immigrant visa under the Immigration Act for the urgent work with the period of not exceeding fifteen days. However, the migrant worker can work after the Director-General or an official received the notification letter, and the Director-General assigns in accordance with the form prescribed by the Director-General. If any work is not defined in the Ministerial Regulations or the work is prohibited for the migrant workers to work as it is prescribed in the Royal Decree, such migrant worker cannot apply for permission to work in Thailand in such career. At present, there is a Royal decree prescribing works relating to occupation and profession in which an alien is prohibited to work (no.2). 1993, and there are 39 occupations that are prohibited for the migrant workers. Upon the prohibited occupations, the works that migrant workers shall apply to work in Thailand have the regulation that the consideration of issuing the work permit to migrant workers shall be considered as it is necessary by the officials. Thus, it is to consider for the benefits on economic, the scramble of Thai occupation, the national security, and the humanitarian principle in accordance with the regulations of the Department of Employment on the criteria for the consideration of applications for work permits of foreigners in 1994.

33. Investment Promotion (BOI) is the issuance of a license for migrant workers to enter the Kingdom in accordance with the law on investment promotion or other laws with provisions on migrants in the same manner, such as the Petroleum Act, Industrial Estate Act, etc. This type of permit may be called in short as Investment Promotion Certificate. The criteria for issuing this type of work permit will be issued to migrants who have legally entered the country, holding a non-immigrant visa and are allowed to work under the conditions set out in the Investment Promotion Law and other laws promoted by the State such as The Investment Promotion Act of 1977, the Industrial Estate Act, 1979, the Petroleum Act of 1978, etc. The period of the work permit shall be as prescribed by the competent authority under each proposed act, and it can be applied for the period of more than 1 years, and the license can be renewed as same as a temporary work permit.

4. The type that is exempted under Section 13 of the Working of Aliens Act, 2008 are those who are being deported due to entering into the Kingdom illegally under the Immigration Act, and are awaiting for deportation, the return of migrant workers born in the Kingdom but not entitling to Thai nationality, and being a migrant worker due to the loss of nationality that is not mentioned in Section 4 of the Working of Aliens Act, 2008. There are also other legal migrants who work in Thailand, but not under the control of applying for a work permit under Working of Aliens Act, 2008. Thus, this is in accordance with the

exception under Section 4 of the Working of Aliens Act, 2008. These migrants can be classified into two sub-groups. The first group of migrant workers is those who have the status of a diplomatic representative, persons in the consular delegation, representatives of Member States, and employees of the United Nations as well as specialists, including personal servants who are from foreign countries and come to work in Thailand with the above mentioned people. The Privilege and Immunities on working in Thailand of such persons are protected under the Prohibition of Act on Diplomatic Privileges and Immunities, 2016 according to Thailand's obligations towards the Vienna Convention on Diplomatic Relations, 1961. The second group consists of migrant workers who have fulfilled their duties or missions under the Thai government's agreement with foreign governments or international organizations as well as persons who perform duties or missions for the benefits of cultural education, martial arts or other sports. Thus, it is as prescribed by the Royal Decree and other persons who are permitted by the government to perform any duty or business. The reason that this group of migrants does not have to apply for work permits like other migrant workers is that this groups of migrant workers is considered by the government to be beneficial to Thailand; hence, it is not necessary to apply for a work permit again.

CONCLUSIONS

Currently, the foreign workers management is still a problem even though Thai government is finding ways to solve the problem, the foreign workers are chosen to illegal way. Thus, it may be due to the fact that the cost of obtaining a work permit is quite high and it must be applied continuously. The most common problems, whether the registration and the application for work permit, the work of migrants is not covered and does not reach migrant workers, the proof of nationality of migrant workers is not accessible to them, and it is costly, or the registration and verification of citizenship is not covered and not reached. Moreover, there are many restrictions, and there is illegal child labor. Additionally, there is an unreachable and unsuitable universal education policy for a child of migrant workers, illegal immigrant labor movements who are taking this opportunity for their benefits, received the assistance from the government officers, and the protection system is not covered to all issues. These are problems waiting for solution and good guideline to correct these issues in the right way.

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THE ANALYSIS OF HEAVY METALS IN WATER PRODUCT USED IN DAILY LIFE OF THE PEOPLE IN THE COMMUNITY FOR BETTER QUALITY OF LIFE

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Abstract - This research is aim at to analysis of heavy metals in water product used in daily life of the people in the community for better quality of life. All of experiments used flame atomic absorption spectrometry technique for determination of the concentration of Co, Cd, Cr and Pb in different types of water product (digested with wet digestion method). The amounts of all heavy ions were determined 3 replicated by Atomic Absorption Spectrophotometer (AAS). The concentrations of metal ions found in all target samples were less than the reported by World Health Organization values (WHO). The results concluded that the water product obtained from Thewet Market were safety to consumption and make the quality of life of people in the community for better quality of life.

Keywords - Heavy metals, Water product, Atomic absorption spectrometry

I. INTRODUCTION

At present, people's lives need to drink water or use water in their lives. All the time we live. We will consume both mineral water, bottled water. Whether to drink to health, beauty treatment or other. We can not deny that our lives have to drink water into the body every day, no matter what form. Based on comfortable one thing we can not overlook is the safety of water consumption. Perhaps everyone may overlook. What could be dangerous or contaminated in drinking water?. Those are heavy metals. Heavy metals, though small, cause disease or harm to the body. There are many types of heavy metals [1].

Heavy metals, both copper and iron, are heavy metals that are important to the body. If it is high in volume or accumulate for a long time. May cause health hazards. Caustics Harmful to the kidneys bones and the cause of cancer. Lead is dangerous to the brain, nervous system and spinal cord anemia can cause kidney failure, kidney failure and death if there is arsenic contamination. Harmful to the gastrointestinal and cardiovascular system, central nervous system press the bone marrow, red blood cells break down easily. There is a higher risk of death from lung cancer, bladder and kidney. It is therefore essential to detect heavy metal contamination in drinking water in the daily lives of people in the Dusit community which is close to SuanSunandhaRajabhat University. In order to improve the quality of life of the people in Dusit community, it is one of the mission of Rajabhat University to be a local university and community and will make the nation sustainable in the future. Heavy metals in drinking water used in everyday life are being investigated [2]. Many researchers have studied how heavy metals are used in consumer products in daily life such.

JiraSuda Pepper, Noppamas ray, found that the problem of contamination of heavy metals such as

cadmium is a matter that creates more anxiety today. Due to the increased amount of water, soil and air, the increased level of contamination may be a natural occurrence or a result of human action. Or as a result of the two parts together. Implementing measures or efforts to control the level and severity of contamination, particularly in animal food products, is not easy in practice. The main cause of the contamination of cadmium in cattle and pig products. Often caused by the presence of contaminated cadmium in food and water. Collection of cadmium in cattle is associated with cadmium contamination in the area. While cadmium accumulation is found in pigs, which can be found in high doses. It can also be found in animals outside the contaminated areas. However, these livestock products may be transported and sold in various areas around the country. Therefore, the opportunity for consumers to get cadmium through livestock products. Especially in animals. May not be different. Consumers should focus on monitoring and monitoring the contamination situation regularly.

It is important to educate the public to avoid getting these harmful contaminants. At the same time, it should push data collection and analysis. The risk of cadmium exposure of the Thai population is present. This is a guideline for appropriate safety measures. Also experience low signal noise and high stability. Which currently has mineral analysis tools. High performance elemental analysis such as Inductively Couple Plasma-Optical Emission Spectrometer (ICP-OES) is an analytical tool. Both qualitative and quantitative tests as well. Analysts have multiple elements at the same time. (Simultaneous Multielements Analysis) using ICP technique are two parts to produce high temperature plasma with argon gas emissions through torch attached to the transmitter frequency. When the frequency into a magnetic field is induced. The

electric Spark with Tesla. A high-energy electrons collide with other electrons. A chain reaction a plasma fraction OES principle makes the transition from the ground state to the substance.

In the work of research A. Boos and the mission of the synthesis of silica using a square and reduce surface tension of a layout, and found that the silica solution was perfectly prepared for osteoporosis is a true 3.90 NM silica can be this type of juice Cu (II) to be 0.20 mol/kg in the NaOH solution NaNO₃, which make the situation for the right to extract Co (II) and Ni (II) with solutions, and it was found that the silica that can extract Co (II) and Ni (II) is 0.30 and 0.32 mol/kg, respectively.

RattanaMaha Chai study the absorbing heavy metal with some kind of local material such as carbon ashes, violin bows, bamboo pulp and fiber corn. IT was found that lead is absorbent material in most nearly all kinds of settings, there is a leader in the range of 30-70% by weight per weight copper, Cadmium, zinc, in the range 2-10% and nickel-chrome bug of sunflower less than 1% when compared to the absorption of metal materials in chronological order are as follows: coconut fiber and silk has the ability to absorb similar metal heavy metal removal when mixed together, found that there are ways a persistent performance in the disposal method is better than non-persistent for about 5 times, but when you put the two together, using the most appropriate material ashes.

Mustafa [3] study to get rid of heavy metal waste, using egg shells and shell black ash, using egg shells and ashes removes cadmium, lead experiment, found that the column performance in elimination of heavy metal and the pH to eliminate Cadmium using egg shells. pH is a good 5-6, which is 99.75 % removal efficiency when using egg shells around 3.28 kg and lead by using the disposal ash black pH is an appropriate 3. Performance in the lead-up to 99.85 % removal when using black ash shell in the amount of 4.58 kg heavy metal removal, it is also dependent on the rate of filter with filter if the slow rate will be high-performance and have been in use for a long time.

Porntip study the absorption efficiency is dependent on temperature burned time and time suitable to absorb the shell with the controls the amount of oxygen will be control oxygen it was found that at a temperature 550 degrees Celsius for 2 hours it takes to absorb 3 hours, and there is effective in absorbing the best burned at a temperature 700 degrees Celsius for 3 hours it takes to absorb and then 48 hours to study the influence of the intensity and pH has an effect on the intensity of absorption was found that 500 mg per liter both of which are effective in absorbing the best pH has an effect on the

absorption of pH, it was found that the capacity of white and black is 0.23 and 0.21 mg, respectively.

The substance is excited to emit light or spectrum analyzer out. For example, in Indian study heavy metal contamination in black tea leaves grown in the city in six areas [4]. Valparai town in Nilgiris Vandiperiyar town of Munnar and Wayanad town of the city. Karnataka total of 100 samples using AAS analysis found that the volume. Of copper, chromium, nickel, cadmium and lead, in the amount of 24.07 ± 2.25 , 4.76 ± 1.27 , 2.53 ± 1.01 , 0.14 ± 0.06 and 0.81 ± 0.32 mg per kg, respectively [5-6]. For Argentina it has used Electrothermal Atomic Absorption Spectrometry (ETAAS) and Ultrasonic Nebulization System Coupled to Inductively Coupled Plasma Optical. Emission Spectrometry (USN-ICP-OES) Determination of Heavy Metals in the tea leaves. And tablets are made Herbs by random sampling from the market. The sample beverages and dry tea leaves. The analysis not found the amount of chromium and cobalt. Because the value is well below the detection limits as can be. Steel, aluminum, cadmium, lead and vanadium have.

But the analysis has been lower than that acceptance by consumers each day (acceptable daily intake), the World Health Organization recommendations and the survey sample digestion with tea [7-8]. Microwave (microwave digestion) and extracted with hot water (hot water extraction), then measure. Boron is in black tea, green tea, coffee, fruit juice. And roasted coffee beans found in large quantities. 3:21 to 9:25, 3:54 to 5:52, from 2.71 to 27.7, from 13.3 to 21.3, and from 7.57 to 17.5 mg per kg, respectively [9-10]. Studies on the absorption of Lead from soil into the tea found that soils with high acidity makes tea tree can absorb lead in soil. It was also found that increasing the alkalinity to the soil by adding calcium carbonate to pH. An increase of one unit can reduce the absorption of lead into the tea percent of 20-50.

The target of this study is to determine the concentrations of Cd, Co, Cr and Pb in water product collected from Thewet Market using flame atomic absorption spectrometry.

II. DETAILS EXPERIMENTAL

2.1. MATERIALS AND METHODS

A. EQUIPMENT

Atomic Absorption Spectrophotometer, the company GBC model AVANTA (Australia)

- Crucible
- Micropipet
- Filler paper No. 1 (Whatman)
- Furnace model Nabertherm (Germany)
- Glassware basic in operation room

B. CHEMICALS SUBSTANCE

- Cd(aq) 1000 ppm [Spectracer UK Ltd]
- Co(aq) 1000 ppm [Merck K GaA]
- Cr(aq) 1000 ppm [Merck K GaA]
- Pb(aq) 1000 ppm [Spectracer UK Ltd]
- Conc. HNO₃ (68-70 %) [BAKER ANALYZED]
- 0.01 M HNO₃

C. SAMPLE PREPARATION

This research prepared standard solution of heavy metal of 4 kinds : Cd, Co, Cr and Pb to have concentration as follow:

0.2, 0.6, 0.8, 1.5, 1.8 ppm for Cd

1.0, 3.0, 5.0, 10.0, 15.0 ppm for Co

0.2, 0.6, 0.8, 1.5, 1.8 ppm for Cr

2.0, 5.0, 10.0, 15.0, 20.0 ppm for Pb

The water products were collected from Thewet Market in Table I and store in refrigerator at 4 °C. Before analysis all sample were filtered with filter paper and add acid to maintain sample pH not over than 6. The samples were digested as following: 10 of each was dissolved in 1M nitric acid (10 ml), boiled to complete the dissolution and filtrated. The obtained precipitate was transferred to 10 ml volumetric flask and fill up to the level with de-ionized water. To determine the amounts of heavy metal by use Atomic adsorption spectrophotometer (AAS).

Table 1: Type of water product used in the present study

No.	Name
1	Type I
2	Type II
3	Type III
4	Type IV
5	Type V

RESULT AND DISCUSSION

The accepted values of the concentrations of Cd, Co, Cr and Pb in water product as reported in the World Health Organization (WHO) were presented in Table 2.

Table 2: Level of heavy metals in water as reported in WHO

Heavy metal	Concentration (mg/L)
Cd	0.012
Co	0.025
Cr	0.030
Pb	0.050

The concentrations of Cd in water products were presented in Table 3.

Table 3: The concentration of Cd in water product

No.	Name	Concentration (mg/L)
1	Type I	0.003
2	Type II	0.004
3	Type III	0.007
4	Type IV	0.005

5	Type V	0.009
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It was found that the concentration of this metal (Cd) was ranged from 0.003mg/L to 0.009 mg/L, which means that, the concentrations of Cd in all examined water products were less than the reported level shown in Table 2.

Table 4: The concentration of Coin water product

No.	Name	Concentration (mg/L)
1	Type I	0.012
2	Type II	0.005
3	Type III	0.019
4	Type IV	0.015
5	Type V	0.009

The results of analysis indicated that the concentrations of the Co in all examined water products varied from 0.009 mg/L to 0.019 mg/L as shown in Table 4 and was less than the standard value.

Table 5: The concentration of Cr in water product

No.	Name	Concentration (mg/L)
1	Type I	0.010
2	Type II	0.006
3	Type III	0.021
4	Type IV	0.015
5	Type V	0.014

The results of analysis indicated that the concentrations of the Cr in all examined water products varied from 0.010mg/L to 0.021mg/L as shown in Table 5 and was less than the standard value.

Table 6: The concentration of Pb in water product

No.	Name	Concentration (mg/kg)
1	Type I	0.010
2	Type II	0.012
3	Type III	0.022
4	Type I	0.019
5	Type I	0.025

Table 6 present the concentration level of Pb in all examined water product samples. The obtained results from this table indicated that the concentrations ranged from 0.010 mg/L to 0.025 mg/L. These values were lower than the accepted values reported in Table 2.

Table 7: The summary of the concentration of heavy metal in water product

No.	Name	Concentration (mg/L)			
		Cd	Co	Cr	Pb
1	Type I	0.003	0.012	0.010	0.010
2	Type I	0.004	0.005	0.006	0.012
3	Type I	0.007	0.019	0.021	0.022
4	Type I	0.005	0.015	0.015	0.019
5	Type I	0.009	0.009	0.014	0.025

The summary of concentration of heavy metal in all examined water products were presented in Table 7. It is very clear that these values are less than the reported values which indicated in Table II.

CONCLUSIONS

The amounts of heavy metal (Cd(II), Co(II), Cr(II) and Pb(II) in all types of water products from Type I, Type II, Type III, Type IV and Type V were lower than the reported values of the World Health Organization (WHO). This result confirmed that all types of water products obtained from The wet Market were safe to consumption for long live living. Because of water and people were related in all dimensions together. People from baby to older were use water all time and everyday. Thus, the safe water will safe quality of life of people forever to reduce the disorder symptom.

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FOUR REGIONAL THAI FOOD WITH CULTURAL TOURISM

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Abstract - The researchers studied on the topic "Four Regional Thai Food with Cultural Tourism." The objective of the study was to study the behavior of Thai tourists towards four regional Thai food and to study types of four regional Thai food to be used for cultural tourism. The population samplings of the study were 400 Thai tourists. The collected data was compiled and analyzed by a computer statistical software program.

The results of the study concerning general information about Thai tourists were as in the following. Most tourists were females more than males, 44 percent. The most ages were between 15-20 year old, 34.3 percent. Most of them are students, 54 percent. The most income was 5,000-10,000 baht per month 26 percent. The most samplings were studying for bachelor's degrees, 70.8 percent. Most of them came from the central region, 49.5 percent. And the last was the type of travel, they used individual travel more than package tours, 85 percent.

The results of the study concerning the behavior of Thai tourists towards four regional Thai food to be used for cultural tourism were as in the following. Most of them travelled during festivals took place and the most duration of time they preceded was about 1-2 days. Most of them travelled for relaxation with their families. For choices of the kinds of food they consumed they liked to have the central Thai food most. They enjoyed having Thai food when they were travelling in Thailand. They spend about 100-500 baht per person for a meal and most meal was lunch.

The results of the recipe of four regional Thai food the tourists liked to have to be used for cultural tourism were as in the following.

For northern Thai food were streaky pork with crispy cracking and chili dip.

For northeastern Thai food were papaya salad and roasted chicken.

For central Thai food was spicy soup with shrimp.

For southern Thai food was seafood.

Keywords - Four regional Thai food, Cultural tourism, Thai tourist

I. INTRODUCTION

The Food is considered one of the key factors of cultural tourism. Because if the tourist travel most of camp, attractions and food. Therefore, the Ministry of tourism and sports, had plans to develop tourism by providing food as a medium to promote the image of tourism in the country, Thailand. And encouraging tourists to arrive in the country for Thailand Tourism culture. The way of life and authentic Thailand cuisine. This will result in an expansion of the money circulating in the economy of Thailand. By the travel industry Council in cooperation with the tourism authority of Thailand and Chulalongkorn University has made a survey of tourists.

Result Tourists give comments on the factors that cause the trip. The first, most beautiful tourist destinations. The second, Thailand's culture and religion. The third, Thai Food and the last this value of money. A well regarded Thailand cuisine is well known among Thailand tourists and foreigners. Because, Thai Food reflection of the culture of eating, Convey the wisdom and Life people of Thailand. So, the selection of raw materials ingredients are unique in each locality. So far, the process of cooking, Layout and decoration to Thai food. To make., Tourist to taste the delicious Thai

food. So, Researchers to study Four Regional Thai Food with Cultural Tourism. Its aim is to study behavior of Thai tourist four regional Thai food with Cultural tourism, And to study types Four regional Thai food with Cultural tourism. [1][2][5][6]

The Objective of Research

1. To study the behavior of Thai tourists Four Regional Thai Food with Cultural Tourism.
2. To study the type of Four Regional Thai Food with Cultural Tourism

II. DETAILS EXPERIMENTAL

2.1. MATERIALS AND METHODS

Research Methodology

The researchers to study on topic concerning Four Regional Thai Food with Cultural Tourism. The objective to study behavior of Thai tourist four regional Thai food with Cultural tourism, And to study types Four regional Thai food with Cultural tourism. The population samplings of this study are the Thai tourist from respondents 400 people. And the collected data was compiled and analyzed by a computer statistical software program.

The formula at W.G.cochran (1953) [3]
Formula

$$n = \frac{P(1-P)Z^2}{d^2}$$

- n = Sample Size
- p = proportion (if not known, use 0.5)
- z = represents confidence; the value is from z - score table

oif confidence at 95%, z = 1.96

oif confidence at 99%, z = 2.58

- d = acceptable error

The instrument used for data collection was a questionnaire. The questionnaire is divided into 3 parts.

Parts 1, to study general information population sample is show that Sex, Ages, Occupation, Income, Educational , Regions and Type of Travel. By selecting a single answer.

It' nominal scale. Result is displayed used were percentage.

Parts 2, to study the behavior of Thai tourist four regional Thai food with cultural tourism. Which Ask a question information about Cultural Attractions, The selected period of travel, The Objective of travel, The Participants travel, The Time interval to tourism, Four Regional Thai Food, Frequency of eating Four Regional Thai Food, The cost of eating Four Regional Thai Food, The reasons for eating Four Regional Thai Food and The Period dining Thailand. By selecting a single answer. The data Scale divided into 5 level. The data Scale divided into 5 level [4].

Level 5 = The Most

Level 4 = Very Good

Level 3 = Moderate

Level 2 = Less

Level 1 = The least

The average level is divided into 5 levels.

4.21-5.00 = The Most

3.41-4.20 = Very Good

2.61-3.40 = Moderate

1.81-2.60 = Less

1.00-1.80 = The least

Result is displayed used were mean and standard deviation.

Parts 3, to study the types Four regional Thai food with Cultural tourism. Which ask a question about.

III. RESULTS AND DISCUSSION

The research to study topic “ Four Regional Thai Food with Cultural Tourism ”. The objective to study the behavior of Thai tourist four regional Thai food with Cultural tourism, And to study types Four regional Thai food with Cultural tourism. The research is a quantitative research, And the population samplings of this study are the Thai tourist 400 samplings through the questionnaire. And the collected data was compiled

descriptive statistics and analyzed by a computer statistical software program. The finding research statistics used were percentage, frequency, means and standard deviation. The results of the study are as in the following :

1. GENERAL INFORMATION OF THE SAMPLE

Table 1: General information of the population sample

General Information	Percentage
1. Sex	
Male	28
Female	72
Total	100
2. Age	
15-20 year old.	34.3
21-25 year old.	26.3
26-30 year old.	7.5
31-35 year old.	7.8
36-40 year old.	4.8
41-45 year old.	7.3
46-50 year old.	3.0
More than 51 year old.	9.3
Total	100
3. Occupation	
Student	54.3
Official	27.0
Employees	12.0
Enlrepreneur	2.8
Not Occupation	4.0
Total	100
4. Monthly Income	
Less than 5,000 baht	25.5
5,000 -10,000 baht	26.0
10,001 – 15,000 baht	19.3
More than15,001 baht	29.3
Total	100

General Information	Percentage
5. Educational Level	
Lower than a bachelor's degree	22.8
The bachelor's degree	70.8
The Master's degree	3.8
The PhD degree	2.8
Total	100
6. The Regions	
Northeastern	18.0
North	10.0
Central	49.5
Southern	13.3
Eastern	5.0
West	4.2
Total	100
7. Type of Travel	
Individual	92.5
Package Tour	7.5
Total	100

From Table 1, to study general information population sample is show that Sex, Ages, Occupation, Income, Educational , Regions and Type of Travel. The results of the study are as in the following :

1. The study on Thai tourist found that 400 respondents, females ,72 percent and males, 28 percent.
2. Mostly ages between 15-20 years old , 34.3 percent, the second ages between 21-25 years old, 26.3 percent, the third ages more than 51 year old, 9.3 percent, the fourth ages between 31-35 years old, 7.8 percent, the fifth ages between 26-30 years old, 7.5 percent, the sixth ages between 41-46 years old, 7.3 percent, the seventh ages 36-40 years old, 4.8 percent and the last ages between 46-50 year old, 3.0 percent.
3. Mostly occupation students, 54.3 percent, the second are official, 27.0 percent, the third are occupation Employees, 12.0 percent, the not occupation, 4.0 percent, and the last occupation private business, 2.8 percent.
4. Mostly income more than 15,000 baht, 29.3 percent, the second are monthly income between 5,001 - 10,000 baht, 26.0 percent, the third monthly income is less than 5,000 baht, 25.5 percent and the last are monthly income between 10,001-15,000 baht, 19.3 percent.
5. Mostly educational with bachelor's degree, 70.8 percent, the second educational level lower than a bachelor's degree, 22.8 percent, the third educational level master's degree, 3.8 percent and the last educational level PhD degree, 2.8 percent.
6. Mostly regions central, 49.5 percent, the second regions northeastern, 18.0 percent, the third regions southern, 13.3 percent, the fourth regions north, 10 percent, the fifth regions Eastern, 5.0 percent and the last regions west, 4.2 percent.
7. Mostly Thai tourist are type of travel individual , 92.5 percent and the package tour , 7.5 percent.

2. THE BEHAVIOR OF THAI TOURIST FOUR REGIONAL THAI FOOD WITH CULTURAL TOURISM

Table 2: The behavior of Thai tourist four regional Thai food with cultural tourism

The Behavior of Thai tourist Four Regional Thai Food with Cultural Tourism.		Level Comments		
		\bar{x}	S.D.	Translati on results
The Co Travelers				
1.	Close friends.	3.45	1.14	Very Good
2.	Family and relatives	4.31	.92	The Most

3.	Lovers	2.88	1.48	Moderate
4.	Solo travel	2.05	1.29	Less
5.	Workmate	2.46	1.32	Less
	Overall	3.03	.62	Moderate
The Favorite Time Travel.				
1.	Long Holidays.	4.16	.86	Very Good
2.	Saturday and Sunday.	4.03	.86	Very Good
3.	Weekdays (Monday to Friday).	2.51	1.28	Less
	Overall	3.56	.55	Very Good
Regional Thai Food.				
1.	Northern foods.	3.26	1.16	Moderate
2.	Southern foods.	3.06	1.23	Moderate
3.	Food in central region.	3.99	.87	Very Good
4.	North-Eastern Foods.	3.73	1.02	Very Good
	Overall	3.51	.56	Very Good
Frequency of having Four Regional Thai Food.				
1.	Every time.	3.74	1.04	Very Good
2.	1-2 times.	3.53	.93	Very Good
3.	3-4 times.	3.02	1.01	Moderate
4.	5-6 times.	2.57	.93	Less
5.	More than 7 times.	2.23	1.19	Less
	Overall	3.02	.63	Moderate
The cost of having Four Regional Thai Food.				
1.	Less than 100 baht per meal.	2.83	1.32	Moderate
2.	100-500 baht per meal.	3.59	1.08	Very Good
3.	501-1,000 baht per meal.	3.09	1.09	Moderate
4.	1,001-1,500 baht per meal.	2.61	1.22	Moderate
5.	More than 1,501 baht per meal.	2.41	1.40	Less
	Overall	2.91	.61	Moderate
The reasons for having Four Regional Thai Food.				
1.	Delicious.	4.45	.76	The Most
2.	Identity.	4.24	.84	The Most
3.	Inexpensive.	4.18	.85	Very Good
4.	Good	4.32	.85	The

	environment and atmosphere.			Most
5.	V*arietyof food.	4.22	.88	The Most
	Overall	4.28	.68	The Most
The Period dining Thailand.				
1.	Morning moments.	3.52	1.13	Very Good
2.	Lunchtime.	4.14	.87	Very Good
3.	The evening.	3.84	.98	Very Good
4.	After 21.00.	2.27	1.26	Moderate
	Overall	3.44	.63	Very Good

From Table 2, to study the behavior of Thai tourist four regional Thai food with cultural tourism. The results of the study are as in the following :

1. The behavior of Thai tourist four regional Thai food with cultural attractions festival have mean of 3.92 to very good level. Follow by the temple with mean of 3.67 to very good level. Next to the archeological places and the ancient community with mean of 3.24 to moderate. Then, Thai tourist select to castle with mean of 3.21 to moderate. And the last monuments with mean of 3.03 to moderate.

2. The selected period of travel between 1-2 days with mean of 3.78 to very good level. Follow by Thai tourist selected period a day trip with mean of 3.63 to very good level. Next to the selected period between 3-4 days with mean of 3.20 to moderate level. Then, Thai tourist the selected period between 5-6 days with mean of 2.35 to less level. Lastly, Thai tourist the selected period more than 7 days with mean of 1.86 to less level.

3. The objective of travel to relax with mean of 4.40 to most level. Follow by the to visit relatives with mean of 3.75 to very good level. Next to join a conference and seminar with mean of 2.20 to less level. Lastly, to do business with mean of 2.05 to less level.

4. The co travelers with family and relatives have mean of 4.31 to most level. Follow by Thai tourist to travel close friends with mean of 3.45 to very good level. Next Thai tourist to travel couple with mean of 2.88 to moderate level. Then, Thai tourist to travel workmate with mean of 2.46 to less level. Lastly, Thai tourist to solo travel with mean of 2.05 to less level.

5. Favorites time travel , Thai tourist long holidays with mean of 4.16 to very good level. Follow by Thai tourist weekend with mean of 4.03 to very good level. And the last go to travel weekdays with mean of 2.51 to less level.

6. Regional Thai food, Thai tourist selected having food in central region with mean of 3.99 to very good level. Follow by selected having north-eastern regional with mean of 3.73 to very good level. Next , Thai tourist selected having northern regional with mean of 3.26 to moderate level. Lastly, Thai tourist selected having southern regional with mean of 3.06 to moderate level.

7. Frequency of having four regional Thai food every time with mean of 3.74 to very good level. Follow by between 1-2 times with mean of 3.53 to very good level. Next, Thai tourist having four regional Thai food between 3-4 times with mean of 3.02 to moderate level. Then, Thai tourist four regional Thai food between 5-6 time with mean of 2.57 to less level. And the last Thai tourist four regional Thai food more than 7 time with mean of 2.32 to less level.

8. The cost of heaving four regional Thai food, Thai tourist use cost of having four regional Thai food between 100-500 baht per meal with mean of 3.59 to very good level. Follow by cost of having between 501-1,000 baht per meal with mean of 3.09 to moderate level. Next, Thai tourist use cost of having less than 100 baht per meal with mean 2.83 to moderate level. Then, Thai tourist use cost of having between 1,001 – 1,500 baht per meal with mean of 2.61 to moderate level. And the last cost of having four regional Thai food more than 1,5001 baht per meal with mean 2.41 to less level.

9. The Reasons for having Thai food of Thai tourist delicious with mean of 4.45 to most level. Follow by good environment and atmosphere reasons for having Thai food with mean of 4.32 to most level. Next, identity with mean of 4.24 to most level. Then, variety of food with mean of 4.22 to most level. And the last inexpensive with mean of 4.18 to very good level.

10. Time consuming, Thai tourist selected at noon wit mean of 4.14 to very good level. And in the evening with mean of 3.84 to very good level. Next, in the morning with mean of 3.52 to very good level. Lastly , late evening with mean of 2.27 to moderate level.

Table 3: Types four regional Thai food with cultural tourism

Types Four regional Thai food with Cultural tourism	Level Comments			
	\bar{x}	S.D.	Translation results	
Northern's Foods				
1.	Streaky pork with crispy crackling and Northem style chillidip.	3.81	1.16	Very Good
2.	Northern Thai spicy sausage	3.70	1.15	Very Good
3.	KhaoSoi Recipe	3.40	1.25	Moderate
4.	Hang-le curry	2.87	1.29	Moderate
5.	Rice noodles with spicy pork sauce	3.62	1.31	Very Good
	Overall			
North-Eastern Foods.				
1.	Papaya salad and Roast chicken	4.56	.76	The Most

2.	Spicy minced pork, beef, chicken	4.48	.74	The Most
3.	Hot and Spicy Soup with Pork Ribs	4.37	.94	The Most
4.	Gaeng Om	3.86	1.29	Very Good
5.	Rice noodles in fish curry sauce with vegetables	3.87	1.31	Very Good
<i>Overall</i>				
Food in Central Region.				
1.	Spicy soup with shrimp	4.64	.67	The Most
2.	Green curry chicken in coconut milk	4.28	1.08	The Most
3.	Thai fried noodle	4.10	1.08	Very Good
4.	Spicy noodle salad or Spicy vermicelli salad	4.27	.95	The Most
5.	Rice Noodles in sweet curry sauce	3.45	1.35	Very Good
<i>Overall</i>				
Southern Foods.				
1.	Sea food	4.60	.81	The Most
2.	Sour soup made of Tamarind Paste	3.51	1.39	Very Good
3.	Stir-Fried Twisted Cluster Bean with Shrimps "Southern Thai Style"	3.12	1.51	Moderate
4.	Pork with yellow curry paste	3.29	1.48	Moderate
5.	Shrimp-paste sauce	3.73	1.33	Very Good
<i>Overall</i>				

CONCLUSIONS

The researchers to studied on the topic "Four Regional Thai Food with Cultural Tourism." The objective of the study were to study the behavior of Thai tourist towards four regional Thai food And to study types of four regional Thai food to be use for cultural tourism. The population samplings of the were 400 Thai tourists. the collected data was compiled and analyzed by a computer statistical software program.

The results of the study concerning general information about Thai tourists were as in the following. Most tourists were females more than males, 44 percent. The most ages were between 15-20 year old, 34.3 percent. Most of them are students, 54 percent. The most income was 5,000-10,000 baht per month 26 percent. The most samplings were studying for bachelor's degrees, 70.8 percent. Most of them came from the central region, 49.5 percent. And the last was the type of travel, they used individual travel more than package tours, 85 percent.

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The results of the study concerning the behavior of Thai tourists towards four regional Thai food to be used for cultural tourism were as in the following. Most of them travelled during festivals took place and the most duration of time they precede was about 1-2 days. Most of them travelled for relaxation with their families. For choices of the kinds of food they consumed they liked to have the central Thai food most. They enjoyed having Thai food when they were travelling in Thailand. They spend about 100-500 baht per person for a meal and most meal was lunch.

The results of the recipe of four regional Thai food the tourists liked to have to be used for cultural tourism were as in the following.

For northern Thai food were streaky pork with crispy cracking and chili dip.

- For northeastern Thai food were papaya salad and roasted chicken.
- For central Thai food was spicy soup with shrimp.
- For southern Thai food was seafood.

Corresponding to BenyaphaYoophothong.(2015) research study, This research aimed to study the behavior and satisfaction of international tourists toward Thai street food in the Bangkok Metropolis.[5]

SUGGESTIONS

The feedback from the research : "Four Regional Thai Food with Cultural Tourism." The objective of the study were to study the behavior of Thai tourist towards four regional Thai food And to study types of four regional Thai food to be used for cultural tourism. To be used by government agencies to develop cultural tourism.

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GUIDELINES FOR SUFFICIENCY ECONOMY DEVELOPMENT FOR SUCCESSFUL SUSTAINABLE COMMUNITIES

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Abstract - The purposes of this study were 1) to study the guidelines for community development in accordance with Sufficiency Economy Philosophy for sustainable success 2) To study the level of success in community development in accordance with the Sufficiency Economy Philosophy of the community. This is a quantitative research and the questionnaires were used as a tool for data collecting. The sample group is the 200 people living in Dusit District Community. The results showed as follow;

1. Enable factors in community development achievement based on the sufficiency economy philosophy of Dusit Community are external factors such as educating, funding factor, technology (social media). In terms of internal factors such as cooperate with the villagers, in line with the daily life, culture and the understanding of villagers about the concept of Sufficiency Economy Philosophy. These factors were effect to the community to be sustainable in the community for long term.

2. Dusit Community succeed in using the sufficiency economy philosophy for successful sustainable communities at a high level in all factors.

Keywords - Dusit community, The Sufficiency economy Philosophy, Development

I. INTRODUCTION

Current socio-economic changes in the world especially the flow of globalization and the competition in capitalism.as a result, Thailand faces a number of challenges. So that Thailand can stand strong in the world society and do not lose your self. In the process of preparing the 10th National Economic and Social Development Plan (2007-2011), the focus has been on the implementation of Sufficiency Economy Philosophy as a guideline for the development strategy [1]. The country to sustainable balance and good immunity by the concept of sufficiency economy. It is a philosophy that guides the way people live and work at all levels, from family to community level to the state. The development and management of the country to the middle way, especially the economic development to keep peace with the world of globalization. It is a philosophy that points to their practices with respect to reasonable modesty and good immunity to be ready for risk [2]. On the basis of knowledge prudence, prudence and virtue be careful and careful. Along with non-encroachment, sharing helps each other. Harmony in society it will create links connecting people in different sectors of society together positive force lead to harmonious, balanced and sustainable development and readiness for change under the Globalization. In the 10th National Economic and Social Development plan, the mission of community development under the concept of sufficiency economy is to be defined as 5 aspects: 1) To emphasize the development of the quality of people in the country, to have knowledge, moral and social foundation. Knowledge is immune to change. 2) Reform the economic structure competitive and fair. 3) Strengthen the equality and strength of the

community and society. 4) Maintain the diversity of natural resources and preserve the quality of the environment. To provide the community with knowledge and immunity have the right to access and manage resources. Conservation of biodiversity resources to be a stable base of Thai society and 5) To develop a system of governance for good governance at all levels. Decentralization has strengthened democracy management with transparency Public Responsibility and there is justice [3]. The government has embraced the Sufficiency Economy Philosophy to be used in the administration of the country and included in the 10th National Economic and Social Development Plan make people know the principles of sufficiency to use in daily life. With the promotion of all sectors and all provinces, the Sufficiency Economy has started. PhraNakhon Si Ayutthaya is an area that embraces Sufficiency Economy Philosophy. The importance of economic concepts suffice it to use in community development. Because Bang Khla community is short, most of the population is 90%. The remaining 10 percent are employed in general. Personal Care And animal husbandry In the past, Bangkaew community has experienced a lot of problems in agriculture. The agricultural output of the villagers produced most of the food but not enough. Or sometimes not enough to eat too. production in the past was primarily aimed at sales. For reasons that need to meet their passion and passion, they want to have something they have never had before. Or ignorance do not understand the trend or for other reasons, for the survival of themselves and their families in society. At the same time, the villagers recruited various methods of applying the farming methods but never achieved concrete results. But it creates more debt and problems for the villagers [4-6]. From this problem, the villagers

began to realize and to find solutions to problems that see concrete results. It is a group of people to gather together to seek knowledge. In farming from the organization, external network and ask for help. Support from government agencies at first, the villagers learned to adjust themselves at one point, the farmer groups of Ban Bang KraLek community. He has been trained in the project to develop the potential and quality of life of the life sciences. The knowledge of composting such as dishwashing, shampoo, laundry detergent and water after training [8-9]. The knowledge that has been transmitted to people in the village. There were groups in the village, and later groups were grouped together. For the convenience of management services and the activities of the groups. It is open to the study of people in and outside the village with the enthusiasm and readiness of the villagers to actively solve the problems of the community. It is a community of prototypes in implementing sufficiency economy concept for community development by the Department of Community Development [10]. The staffs have been dispatched to teach the community how to apply the sufficiency economy philosophy. It also provides knowledge and co-operation to the community in community environmental management.

II. DETAILS EXPERIMENTAL

A. OBJECTIVE OF THE STUDY

1. To study the guidelines for community development in accordance with Sufficiency Economy Philosophy for sustainable success.
2. To study the level of success in community development in accordance with the Sufficiency Economy Philosophy of the community.

Method

Population and sample

The population in this study The people living in the community, Dusit. Bangkok Determining the sample size The study used a sample size. Know population definite Represented by the following formula Yamane.

The number of respondents = 200

Thus, the number of samples in the housing Dusit community. After the study was conducted Sampling to collect the data. Head of household or household members Dusit community and has a total of 200 people.

Tools used in research

The instrument used in this study was a questionnaire survey. A closed end and open-end break into six parts

Data collection

Perform the following steps:

This research Researchers conducted a study and collect data from various sources, as follows.

1. The primary data The researchers used questionnaires Collect data on people living in the Dusit community.
2. Secondary The research was carried out to collect information from books, journal articles, online media, as well as research on the concept of sufficiency economy. Sustainability Just embrace the concept used in the development of various social and so on.

B. HYPOTHESIS FOR STUDY

Sufficiency Economy help develop for successful Sustainable Communities.

C. TOOLS USED IN THE RESEARCH

The research is as follows:

1. The research community is in Dusit District, Bangkok.
2. The variables used in the Research are :
 - 2.1 Variables is the beginning of community development.
 - 2.2 Variable is the result of the achievement of sufficiency economy philosophy.

How to do research

This research is carried out as follows :

1. Population and sample group population. The population used in this research consists of population for developed a variety of community development and sustainable growth in the user research has created and developed.

Sample group use the selection by Purposive Sampling with the sample group of 100 people. That is used to make the selection from this research group. The above population by selecting a specific (Purposive Sampling) is a representative to join the program at a organization of 100 people, as well as all the criteria considered.

2. Tools.

2.1 The tools used in the study.

2.1.1. The tools for collected data in the form of a draft from a organization of the 100 people who are in-depth interviews.

2.1.2. Delphi Technique is a tools to used to test the community development based on Sufficiency Economy Philosophy

1) Pattern for the test about community development based on Sufficiency Economy Philosophy.

2) The survey of the think of experts.

2.2 Tools to research.

There was an interview with a Structured Interview. A Opened interview with community development based on Sufficiency Economy Philosophy by the occasional to be able to answer a

question with a very independent concept is the question.

There is a method as describe below :

1) Theory and document research, that is with the Sufficiency Economy Philosophy.

1.1) The theory that occur in the development

1.2) The organization development.

1.3) Output of the development.

1.4) Process of the development.

1.5) Other documents.

2) Workshop described as below:

2.1) To study the data in Dusit District, Bangkok.

2.1.1.) To study organization problem.

2.1.2.) To study community development based on Sufficiency Economy Philosophy.

2.2) Brainstorming.

3) Sandel's froth used to process for the community development based on Sufficiency Economy Philosophy.

3. Data collection

3.1 Data collection questionnaire from the experts is as follows:

3.1.1. The research has a question in the process and want to give details, or more comments.

3.1.2 Delivery by post.

3.1.3. Interview form with a representative from the Dusit District community.

3.1.4. Verify and collect data of all datas.

3.1.5. All of the interviews to create a form of community development based on Sufficiency Economy Philosophy

D. DATA ANALYSIS

1. Used a computer program to collect a data analysis.

2. The characteristics of tools for the improvement tool.

The relationship between the objective as below :

The statistics used in the data analysis.

1. Statistics used

1.1 Percentage value.

1.2 Median value

1.3 Interquatile Range

2. The statistics used in the analysis tool to find quality of tool.

2.1. Validity

2.2. Reliability

RESULT AND DISCUSSION

Community development based on Sufficiency Economy Philosophy to succeed sustainable must rely on many factors. The factors within the community include: The cooperation of the villagers who lived in the community, lifestyle, culture and traditional knowledge that contributes to the development of sustainable communities. And the most importantly is knowledge of the villagers in the philosophy of Sufficiency Economy. In addition,

there are external factors in the community, such as the provision of knowledge in various aspects of the philosophy of Sufficiency Economy, funding from various agencies and public relations provide useful information to villagers living according to the Sufficiency Economy Philosophy to make the community sustainable.

In terms of external factors is educating of the content that is relevant to community development in accordance with the philosophy of Sufficiency Economy is very important because the community has a concept and a clear development. The crystallization of the concept is linked to a developmental approach and united finally to sustainability. Mostly educated is related to the application of sufficiency economy philosophy to sustainable community development by providing such knowledge to the villagers in the community from the people involved in community development. And who have expertise in the application of sufficiency economy philosophy in community development such as government officials and the philosophers. In terms of funding factor is External factor is also important because they come from outside the community. Transparency in the use of such funds is a matter for which the community must be extra cautious. And the use of such funds must be used to generate real community development. In particular, it will also increases the opportunities for technology that the community can use these funds to provide appropriate technology for use and facilitate the development of sustainable community. This will be the answer to the funding to meet the true purpose of the agency. The final external factor is the publicity Provide useful information. In this aspect of the present have social media and technology has helped to promote the information to reach the people in the community faster and more accurately. Therefore, most villagers in the community can receive information better. And recognize the correct information in the same direction, making it easy and simple to develop better community.

In terms of internal factors. The first priority is to cooperate with the villagers in the community. Have the same they have a shared vision to make their communities sustainable through the philosophy of Sufficiency Economy. The cooperation of the villagers in the community itself is a great power that can be driven in the same direction. And equally important, it is community development according to the philosophy of Sufficiency Economy to must comply with the social, in line with the daily life of the villagers and it is compatible with the culture and ethnicity of the villagers in the community. Do not create alienation or make people in the community uncomfortable in order to implement community development in accordance with the philosophy of Sufficiency Economy. The development of the

community according to Sufficiency Economy Philosophy still requires knowledge in terms of local wisdom available in the community. The villagers can develop an innovation that reflects the identity that truly reflects the community to be sustainable in the community. And the last factor is the most important is the understanding of villagers about the concept of Sufficiency Economy Philosophy. There are also some villagers who do not understand the philosophy of Sufficiency Economy. It is imperative that all villagers in the community have knowledge and understanding of the philosophy of Sufficiency Economy. Although educating from expert knowledge or those who are involved with the philosophy of Sufficiency Economy are very effective. But the villagers still do not understand the philosophy of Sufficiency Economy. The villagers can not apply the knowledge and the guidelines for community development according to Sufficiency Economy Philosophy to use truly effective. Therefore, villagers in the community, which is an important mechanism to drive the community development according to Sufficiency Economy Philosophy, it is necessary to study and research to understand the concept of Sufficiency Economy Philosophy to the fullest potential. To implement the concept of Sufficiency Economy Philosophy to be applied in the development of the community according to the Sufficiency Economy Philosophy can be efficiency and sustainability.

CONCLUSION

Community development based on Sufficiency Economy Philosophy to succeed sustainable must rely on many factors. In terms of external factors is educating of the content that is relevant to community development in accordance with the philosophy of Sufficiency Economy makes the community has a concept and a clear development united finally to sustainability. In terms of funding factor, It will also increases the opportunities for technology that the community can use these funds to provide appropriate technology for use and facilitate the development of sustainable community. The publicity Provide useful information. In this aspect of the present have social media and technology has helped to promote the information to reach the people in the community faster and more accurately. recognize the correct information in the same direction, making it easy and simple to develop better community. In terms of internal factors. The first priority is to cooperate with the villagers in the community. Have the same they have a shared vision to make their communities sustainable through the philosophy of Sufficiency Economy. It is community development according to the philosophy of Sufficiency Economy to must comply with the social, in line with the daily life of the villagers and it is compatible with the culture and ethnicity of the villagers in the

community. The development of the community according to Sufficiency Economy Philosophy still requires knowledge in terms of local wisdom available in the community. The villagers can develop an innovation that reflects the identity that truly reflects the community to be sustainable in the community. And the last factor is the most important is the understanding of villagers about the concept of Sufficiency Economy Philosophy. There are also some villagers who do not understand the philosophy of Sufficiency Economy. Although educating from expert knowledge or those who are involved with the philosophy of Sufficiency Economy are very effective. But the villagers still do not understand the philosophy of Sufficiency Economy. The villagers can not apply the knowledge and the guidelines for community development according to Sufficiency Economy Philosophy to use truly effective. Therefore, villagers in the community are necessary to study and research to understand the concept of Sufficiency Economy Philosophy to the fullest potential. To implement the concept of Sufficiency Economy Philosophy to be applied in the development of the community according to the Sufficiency Economy Philosophy can be efficiency and sustainability.

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CONCRETE MIXTURE WITH PLASTIC AS FINE AGGREGATE REPLACEMENT

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Abstract- The objective of this research is to investigate the effectiveness of using waste plastic as fine aggregate replacement in concrete mixtures. The compressive and tensile strengths of various concrete specimens were tested to determine how the incorporation of recycled plastic as a replacement fine aggregate would affect the development of strength in the mixes. Six mixes were compared at replacement increments of 0%, 10%, 20%, 30%, 50% and 100%. All stages of plastic replacement showed a noticeable decrease in compressive strength. The 10% replacement level only showed a 15% loss of compressive strength at 28 days compared to the control. Despite being much weaker in compression, the tensile strength test showed that the 10%, 20% and 30% replacement increments were stronger in tension compared to the control. An additional test was conducted to determine whether the plastic aggregate would change the heat absorption and heat transfer of the concrete. This test showed noticeable difference between the test samples and the control. The 10%, 20% and 30% replacement mixes showed a significant decrease in heat absorption, and a minor decrease in heat transfer through the test slab.

Index Terms- Alternative recycling methods, green concrete, plastic, sustainable building materials.

I. INTRODUCTION

Concrete, one of the most common construction materials, requires a large amount of natural resources and energy. Natural resources used in concrete mixtures include lime stone, clay, sand, natural gravel, crushed stone, and water. With the rapid development in urban areas around the world in the recent years, our natural resources are depleting in an ever-increasing rate. Therefore, it is necessary to develop a new material that consumes less natural resources and energy in order to make our construction methods more sustainable. Many efforts have been made to study the use of waste/by product materials, such as fly ash, slag, silica fume, and natural pozzolan, to replace portland cement in a concrete mixture [1-6].

Others [7-12] studied effects of plastic in concrete mixtures as aggregate replacement on material properties. While the previous studies showed potential advantages of using plastics in concrete (e.g., light weight and low energy consumption), they also reported some disadvantages, such as decreases in compressive strength and flexural strength of plastic concrete mixtures with the increase of the plastic ratio in the mixtures. Furthermore, material properties of plastic concrete mixtures may vary depending on the type of plastics that is used in the mixtures. For this reason, it was of interest of this research to study effects of one type of plastics, high-density polyethylene (HDPE), on concrete properties. This paper investigated the application of HDPE plastic on partial/full fine aggregate replacement for concrete mixtures.

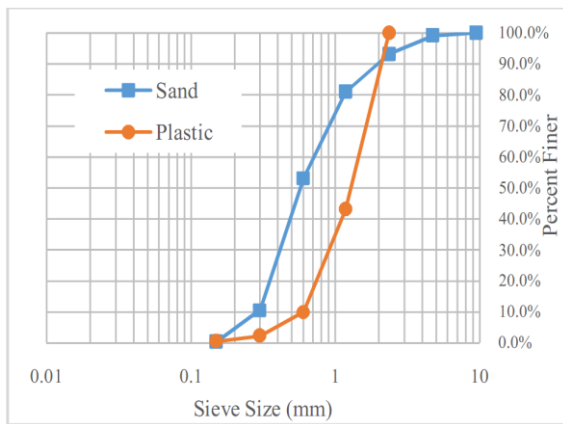
II. EXPERIMENTAL PROGRAM

A. Material Preparation

Concrete materials used in this study included type I portland cement, river sand, $\frac{3}{4}$ inch crushed limestone, and water. Both sand and crushed limestone used in this study conformed to ASTM C33 [13] for concrete aggregates as fine and coarse aggregates. HDPE was selected as the plastic for fine aggregate replacement in this study. The purpose for the experiment was to determine how best to incorporate construction waste materials back into concrete saving both energy and reducing the need to discard plastic waste into landfills. The experiment began by finding the gradation of the fine aggregate owing to that the gradation of sand could provide a baseline for the desired incorporation of recycled HDPE plastic as a fine aggregate replacement option. Sieve analysis was performed on a river sand sample to determine its gradation. The gradation test was conducted in accordance with ASTM C 136 [14], and the results can be found below in Table 1. Initially, the goal was to mimic the sand gradation with the plastic gradation exactly; however, after a sieve analysis of the pulverized HDPE plastic was completed, this was deemed impracticable. As seen in Figure 1, the pulverized HDPE plastic has a much finer gradation than the sand. To accurately replace the gradation of the sand with the plastic, all of the plastic would have had to be sieved, weighted, and then remixed at the correct ratios. This process would have resulted in a lot of wasted plastic, which would have been counterproductive to the green initiative this project intended to propose.

Table 1: Sand gradation

Sieve Number	Diameter (mm)	Mass of plastic Retained (grams)	Percent Retained (%)	Percent Finer (%)
3/8"	9.53	0.0	0%	100.0%
4	4.75	13.6	0.9%	99.1%
8	2.36	89.1	5.9%	93.2%
16	1.18	183.5	12.2%	81.0%
30	0.60	419.1	27.8%	53.2%
50	0.30	641.6	42.6%	10.6%
100	0.15	155.6	10.3%	0.3%
Pan	-	3.9	0.3%	0.0%
Sum =		1506.4		

**Figure 1 Gradation of sand and HDPE plastic**

Further analysis of the pulverized plastic revealed that the plastic retained on the #8 sieve and larger was flat and elongated. Therefore, these sizes were disregarded, collected and re-pulverized. The increased surface area from the strips would have caused a destabilization of the concrete mixture. Also the elongated strips would have incorporated slick surfaces within the concrete, which could prevent the cement from properly adhering to the aggregate. After removing the flat and elongated pieces, another sieve analysis was performed, and the results can be found in Table 2.

Table 2: Plastic gradation from pulverization

Sieve Number	Diameter (mm)	Mass of plastic Retained (grams)	Percent Retained (%)	Percent Finer (%)
8	2.36	0.0	0.0%	100.0%
16	1.18	199.1	57.0%	43.0%
30	0.60	115.4	33.0%	10.0%
50	0.30	27.2	7.8%	2.2%
100	0.15	6.1	1.8%	0.5%
Pan	-	1.6	0.5%	0.0%
Sum =		349.5		

In order to compensate for the removal of the #8 sieve size and above, and to model better the initial gradation of the sand, HDPE plastic pellets were added to the pulverized plastic. The quantity of pellets added was based on the original gradation of the river sand. The design gradation determined for the tests can be found in Table 3. The percent of pellets added to the plastic was based on the percent retained on the #4 and #8 sieve of the sand, i.e., the percent retained on the #4 and #8 sieve from the sand gradation (Table 1) equals the percent retained on the #8 sieve for the plastic (Table 3).

Table 3: Plastic gradation used in mix for design

Sieve Number	Diameter (mm)	Percent Retained (%)	Percent Finer (%)
4	4.75	0%	100%
8	2.36	6.8%	93.2%
16	1.18	53.1%	40.1%
30	0.60	30.8%	9.3%
50	0.30	7.3%	2.1%
100	0.15	1.6%	0.4%
Pan	-	0.4%	0%

B. Mix Design

Using the aforementioned materials, mix proportions for one control mix and five experimental mixes were created. The control mix was designed with a 0.5 water to cement ratio. The mix design was determined so that a reasonably concrete strength would be achieved to adequately determine the strength degradation induced by the increasing quantity of plastic. The experimental sample mixes utilized the same mix design with the exception of the fine aggregate. Mix designs for the control mix and the five experimental mixes with varying fine aggregate replacement levels are shown in Table 4.

The water content of the actual batch weight was adjusted to account for the absorption of the aggregates. For the HDPE plastic, due to the susceptibility of plastic to heat, an absorption test requiring heating samples in an oven was difficult to perform. Based on the manufacturer specifications, the HDPE plastic had an absorption between 0% and 0.1%. Therefore, for the purpose of this experiment, it was assumed that the HDPE had no absorption. Recycled white HDPE plastic resin was used for the experiment to amplify the potential reflectivity of the concrete. The HDPE plastic replaced the sand by volume. As mentioned previously, both the HDPE plastic and the sand were in a state of 0% absorption. Therefore, as the volume of sand was reduced and plastic added, the water content in the sample mixes did not need to be adjusted.

Table 4: Mix proportions (kg/m³) of the control and sample mixes

Material	Control	10%	20%	30%	50%	100%
CA (SSD)	1098	1098	1098	1098	1098	1098
FA (SSD)	829	746	663	580	414	0
Cement	307	307	307	307	307	307
Water	153	153	153	153	153	153
Plastic	0	14	27	41	68	137

C. Test Procedures

After the concrete mixtures were properly mixed, the temperature of the batch was recorded. Then the air content was determined using the pressure method in accordance with ASTM C231 [14]. Also, the slump of each concrete mix was measured according to ASTM C143 [15]. Seven 100 mm (diameter) x 200 mm (height) cylinders and one 305 mm (width) x 305 mm (length) x 25 mm (thickness) slab were produced for each mix. Cylinder specimens were made following ASTM C31 [16]. The cylinders were used for compression and tension tests, and the slab was used for testing the heat absorption of the control and experimental samples. The specimens were initially cured for twenty four hours and then placed in a water tank and cured for twenty seven days. Two cylinders were broken at seven days, fourteen days, and twenty eight days following ASTM C39 [17]. The splitting tensile strength was measured with the last cylinder. The cylinder was cut in half and the splitting tensile strength was performed on both specimens. The slabs were initially cured for twenty four hours and then removed from the molds and placed in a water tank for twenty seven days. For testing, the slabs were placed on a concrete floor. 250 watt heat lamps with reflectors were placed one foot above the slab. The lamps were run for seventy five minutes. The temperatures were measured on the front and back every fifteen minutes with an infrared heat gun.

D. Results and Discussions

Table 5 provides the results of the fresh concrete tests. Due to its light weight property, the plastic aggregate caused a reduction in the unit weight of the concrete. The concrete showed a resistance to compaction, or more appropriately stated, the concrete would only remain compacted temporarily. Immediately after the concrete was rodded or vibrated the plastic acted like a spring. The plastic expanded in order to alleviate the internal stress induced by the compaction, and the expansion, in turn, created an increased air content within the concrete. Furthermore, the slump tests proved futile. Since the plastic caused expansion within the concrete, the slump test could not be considered an indicator of potential workability of the concrete with plastic as partial/full fine aggregate replacement. In the case of the 100% replacement sample, the slump cone grew in size, hence a negative slump value was recorded. Although the slump for the control and 10% replacement was very low, the actual condition for the control and 10% replacement

samples was considered workable. The mixes with plastic replacement levels beyond 10% showed significant loss in workability. Especially, for the 50% and 100% replacement levels, the mixes showed lost cohesion and exhibited unworkable conditions. The measured temperatures for all samples were comparable.

Table 5: Fresh concrete properties of test specimens

Percent Replacement (%)	Slump (mm)	Temperature (°C)	Air Content (%)	Unit Weight (kg/m ³)
0	0	18	2.1	2,387
10	5	16	2.3	2,323
20	0	17	2.3	2,243
30	0	19	4.4	2,179
50	5	17	5.6	2,034
100	-5	17	10.2	1,698

Table 6 and Table 7 show the compressive strength and strength loss of test specimens, respectively. Results showed a significant variation in the strengths of the concrete samples. As the percentage of plastic replacing the sand increased, the compressive strength of the concrete decreased. At 10% replacement of the fine aggregate with HDPE, the strength of the concrete decreased by approximately 15%. Likewise, at 20% replacement, over 30% of the compressive strength of the concrete was lost. The 50% and 100% replacement samples lost cohesion and suffered from extreme loss of compressive strength. Additionally, both samples were found to be pervious. This was likely due to the unusual shape of the HDPE aggregate and the excessively high air content. The 28 day compressive strengths for the 30% plastic replacement sample turned out to be unusually weak. The reason for this anomaly was uncertain and warranted further investigation. The most likely explanation was that the cylinders broken at 28 days were poorly compacted or otherwise flawed, and these internal flaws caused the cylinders to break prematurely. It would be highly unusual for a 28-day compressive strength to be below the 7-day and 14-day compressive strengths for the same batch of concrete.

Table 6: Compressive strength of test specimens

Percent Replacement (%)	Compressive Strength		
	7-day (MPa)	14-day (MPa)	28-day (MPa)
0	26.7	37.3	41.2
10	22.9	32.5	35.2
20	18.3	24.8	28.0
30	12.1	18.2	8.1
50	6.2	9.8	9.5
100	0.8	0.9	1.1

Table 7: Compressive strength loss

Percent Replacement (%)	% Strength Loss vs. Control		
	7-day (%)	14-day (%)	28-day (%)
0	0.0	0.0	0.0
10	14.2	12.9	14.6
20	31.5	33.5	32.0
30	54.7	51.2	80.3
50	76.8	73.7	76.9
100	97.0	97.6	97.3

The split-cylinder tests showed a different result as compared to that of the compression tests, i.e., the compression tests showed a loss of strength with the increase of plastic while the split-cylinder tests showed the opposite. As can be seen in Table 8, the control batch was weaker in tension than the 10%, 20% and 30% replacement mixes. Even the 30% replacement mix which was over 50% weaker in compression vs the control mix, was 2% stronger in splitting tensile strength. It appeared that the addition of HDPE plastic caused fundamental changes the way that concrete behaved. It was likely that the inherent stringiness of the plastic (a byproduct of the shredding/pulverizing process) provided internal shear and tensile reinforcement. The plastic behaved in a similar fashion to the way steel and synthetic fiber reinforcement fortified the concrete inhibiting the spread of cracks and fractures. Determining the optimum level of plastic replacement of the fine aggregate to attain the greatest tensile strength would require additional research and testing. The optimum amount of plastic cannot be directly interpolated because the tensile strength is dependent on two distinct variables: the compressive strength of the concrete and the amount of plastic in the mix. Additional study will be necessary to determine how each of the variables affect the tensile strength.

Table 8: Splitting tensile strength of cylindrical test specimens

Percent Replacement (%)	Splitting Tensile Strength (MPa)
0	3.15
10	3.30
20	3.70
30	3.20
50	2.80
100	0.20

There was a significant difference in the amount of heat absorbed by the concrete samples that incorporated plastic to replace the sand in the concrete mixture. Table 9 tabulates the difference in temperatures between the front and back surfaces of the concrete slab. Detailed temperature data measured

during the tests are reported in Appendix. Results showed that the 10%, 20% and 30% aggregate replacement mixes absorbed heat at a slower rate as compared with the control. Furthermore, all of the sample mixes had a higher temperature differential between the front and back of the slabs compared to the control mix. The 50% and 100% replacement levels showed a much higher temperature differential compared to the other mixes, but they also absorbed much more heat than the other mixes. It is likely that at these higher replacement levels, the higher air content in the concrete inhibited the transfer of heat through the slab. Additionally, at the 50% and 100% replacement levels, the plastic was visible on the surface of the slabs. It is possible that the plastic on the surface absorbed a large percentage of the heat, preventing its ability to pass through the concrete slab.

Table 9: Temperature differentials measured from thermal conductivity tests

Percent Replacement (%)	Temperature Differential (°C)				
	15 mins	30 mins	45 mins	60 mins	75 mins
0	0.6	1.1	2.2	4.4	1.4
10	4.2	-0.8	1.7	4.4	3.9
20	5.0	1.1	5.0	10.6	4.4
30	3.9	3.3	2.8	1.9	2.2
50	8.9	6.1	7.8	7.8	5.3
100	27.5	27.8	23.1	26.9	28.3

CONCLUSIONS

The following conclusions can be drawn from this research study:

1. The temperature of the fresh concrete containing the HDPE plastic was comparable to that of the ordinary concrete.
2. The air content of the test samples increased with an increase in the percent replacement. The increase in air content was more significant when the percent replacement is greater than 30%.
3. Owing to the expansion caused by the HDPE plastic within the concrete, the slump test results could not be used as an indicator for the workability of concrete containing the HDPE plastic used in this study. For the materials used in this study, the workability of concrete decreased significantly for specimens with the plastic replacement level greater than 10%.
4. As expected, the unit weight of concrete decreased with an increase in the percent replacement owing to the light weight property of the HDPE plastic and the increase of air content due to the plastic replacement.
5. As the percent replacement increased, the compressive strength of the concrete decreased. More than 50% strength loss was observed for specimens with the percent replacement beyond 30%.
6. The 10%, 20%, and 30% replacement samples exhibited higher splitting tensile strength than that of

the control sample. However, such increase was not observed for the specimens with percent replacement greater than or equal to 50%. The results suggested that a proper percentage of fine aggregate replaced by the HDPE plastic may be beneficial to tensile strength development.

7. The increase in the percent replacement increases the air content of the HDPE concrete, inhibiting the transfer of heat through the slab.

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INFLUENCE OF THE FLC'S PARAMETERS OF THE UPQC IN THE DISTRIBUTED GENERATION

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Abstract- The use of Distributed Generation (DG) has been increasing in recent years to fill the gap between both energy supply and demand. This paper presents the reaction of the Fuzzy Logic Controller (FLC) when its parameters change. It is located in the DC voltage control loop of the Unified Power Quality Conditioner (UPQC) which is used to improve the power quality of the distributed generation. The main contribution of this paper concerns the impact of the different parameters of the FLC which are generally used by default in the majority of the published papers. The obtained results show that the change of these parameters affects the compensation's characteristics of the UPQC.

Index Terms- Distributed Generation, Sags voltage, Series active filter, Shunt active filter, UPQC, Wind turbine.

I. INTRODUCTION

With the augmentation of electrical energy consumption in the world- due to the process of industrialization, the electrical power generation by classical methods needs increase to fill the gap between demand and supply by using new clean generation techniques, such as, wind, solar, and micro turbines. These alternative methods are called dispersed or Distributed Generation (DG) of electrical energy. Environmental policies or concerns are probably the major driving force of the demand for distributed generation in Europe. Environmental regulations force players in the electricity market to look for cleaner- energy and cost-efficient solutions. Many of the distributed generation technologies are recognized environmentally friendly [1].

The development of power electronic technology makes it possible to realize many kinds of Flexible Alternating Current Transmission Systems devices to obtain high quality electric energy and enhance the control over power system. As result of this innovation, the implementation of Active Power Line Conditioner like Unified Power Quality Conditioner (UPQC) in DG systems to improve the power quality is gaining greater importance. The Unified Power Quality Conditioner, UPQC, is a worthwhile equipment that provides power quality compensation since it is able to mitigate power quality issues of the utility current and of the load voltage, simultaneously. In this way, many studies have been focused on improving the UPQC effectiveness and robustness, as well as ensuring its viability in high power grids [2] [3].

The main contribution of this paper concerns the impact of the different parameters of the FLC which are generally used by default in the majority of the published papers. The obtained results show that the change of these parameters affects the characteristics of compensation which are represented by the THD value.

II. DESCRIPTION OF THE SIMULATED SYSTEM

The simulation in (Fig.1) concerns a distributed generation system which contains a FACTS device called UPQC based Fuzzy Logic Controller, two passive filters which are tuned on the harmonics of rank 5 and 7 and both loads linear and non linear. The wind speed is maintained to 10 m/s. The generator is an asynchronous model. The wind energy is transformed into mechanical energy by wind turbine whose rotation is transmitted to the generator by a mechanical drive train [4].

The equations below present the modeling of the wind turbine:

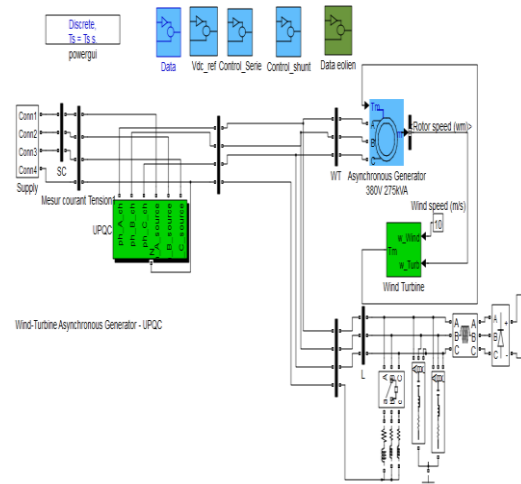


Fig. 1 The simulated system

$$P_t = \frac{1}{2} \rho \pi r^2 V^3 C_p(\lambda, \beta) \quad (1)$$

$$C_p(\lambda, \beta) = \frac{1}{2} (\Gamma - 0.022\beta^2 - 5.6) e^{-0.17\Gamma} \quad (2)$$

$$\lambda = \frac{w \cdot r}{V} \quad (3)$$

$$\Gamma = \frac{r \cdot (3600)}{\lambda \cdot (1609)} \quad (4)$$

where, P_i [W] is the extracted power from the wind, ρ is the air density [kg/m³], r is the turbine radius [m], V is the wind speed [m/s], β is blade pitch angle [deg], ω is the rotational speed [rad/s], C_p is the turbine power coefficient which represents the power conversion efficiency and is a function of the ratio of the rotor tip-speed to the wind speed, λ is the tip speed ratio of the rotor blade tip speed to wind speed.

The torque coefficient and the turbine torque are expressed as follows [5-6]:

$$C_t = \frac{C_p \cdot (\lambda)}{\lambda} \quad (5)$$

$$T_M = \frac{1}{2} \rho C_t (\lambda) \pi r^3 V^2 \quad (6)$$

III. UNIFIED POWER QUALITY CONDITIONER

UPQC is the integration of series and shunt active filters, connected back-to-back on the DC side, sharing a common DC capacitor. The series active filter of the UPQC mitigates the supply side disturbances: voltage sags/swells, flicker, voltage unbalance and harmonics. It inserts voltages so as to maintain the load voltages at a desired level; balanced and distortion free. The shunt active filter is responsible for mitigating the current quality problems caused by the consumer: poor power factor, load harmonic currents, load unbalance. It injects currents in the ac system so that the source currents become balanced sinusoidal and in phase with the source voltages. A basic functional block diagram of a UPQC controller is shown in Fig. 2 [7].

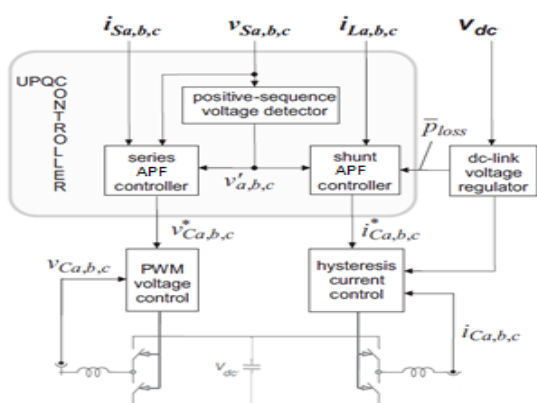


Fig. 2 Functional block diagram of a UPQC controller

A. UPQC control strategy

The control strategy can be separated to shunt strategy, series control strategy and DC capacitor control.

1. Shunt control Strategy

The shunt active filter (SHAF) is provided by the current and the reactive power (if the system needs) compensation. It acts as a controlled current generator that compensated the load current to force the source currents drained from the network to be sinusoidal,

balanced and in phase with the positive-sequence system voltages.

2. Series Control Strategy

The series active filter (SAF) is provided by the voltage compensation. It generates the compensation voltage that synthesized by the converter and inserted in series with the supply voltage, to force the voltage at PCC to become sinusoidal and balanced.

3. DC Voltage controller

In compensation process, the DC side voltage will be changed because UPQC compensates the active power and the losses of switches, etc. If the DC voltage is not the same as the rating value, the output voltage of the series active filter will not equal to the compensation value. The compensation will not be correct. It is the same with the shunt active filter. The DC voltage regulator is used to generate a control signal to keep the voltage constant. It forces the shunt active filter to draw additional active current from the network. A fuzzy logic controller (FLC) converts a linguistic control strategy into an automatic control strategy, and fuzzy rules are constructed by expert experience or knowledge database. Firstly, the error $e(t)$ and the variation error $\Delta e(t)$ have been placed of the angular velocity to be the input variables of the FLC. Then the output variable of the FLC is presented by the control voltage $u(t)$. In this work, the type of fuzzy inference engine used is Mamdani type. The linguistic variables are defined as (NB, NM, NS, Z, PS, PM, PB) which mean Negative Big, Negative Medium, Negative Small, Zero, Positive Small, Positive Medium and Positive Big respectively. The fuzzy inference mechanism used in this work is given by Equation (7).

$$\mu_B(u(t)) = \max_i^m [\mu_{A1j}(e(t)), \mu_{A2j}(\Delta e(t)), \mu_{Bj}(u(t))]$$

Fuzzy output $u(t)$ can be calculated by the centre of gravity defuzzification as:

$$u(t) = \frac{\sum_i^m \mu_B(\mu_i(t)) u_i}{\sum_i^m \mu_B(\mu_i(t))} \quad (8)$$

Decision table (Table I) shows 49 rules of the two inputs (e and Δe) and one output (Δu). The example of the first rule is: If e is NB (Negative Big) and Δe is PB (Positive Big) then Δu is Z (Zero). The output is obtained by applying a particular rule according to the input values.

Table I
Decision table

Δu		e						
		NB	NM	NS	Z	PS	PM	PB
Δe	PB	Z	PS	PM	PB	PB	PB	PB
	PM	NS	Z	PS	PM	PB	PB	PB
	PS	NM	NS	Z	PS	PM	PB	PB
	Z	NB	NM	NS	Z	PS	PM	PB
	NS	NB	NB	NM	NS	Z	PS	PM
	NM	NB	NB	NM	NM	NS	Z	PS
	NB	NB	NB	NB	NB	NM	NS	Z

IV. DESCRIPTION OF THE FLC'S PARAMETERS

The FIS Editor opens and displays a diagram of the fuzzy inference system with the names of each input and output variables.

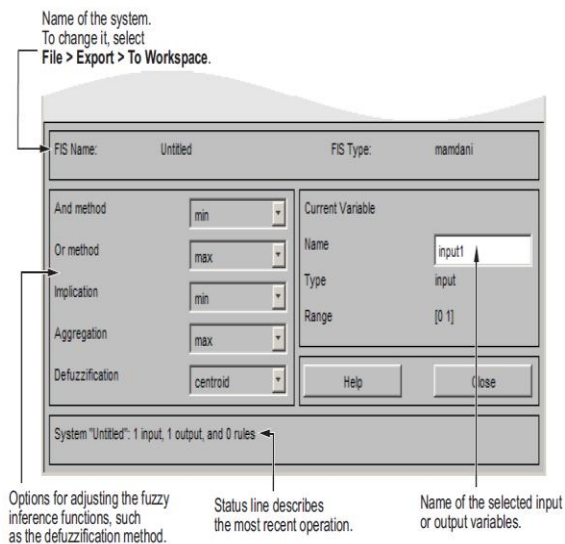


Fig. 3 FIS properties

Five pop-up menus are provided to change the functionality of the five basic steps in the fuzzy implication process:

- **And method:** Choose min, prod, or Custom, for a custom operation.

Min: It resolves the statement A AND B, where A and B are limited to the range (0,1), by using the function $\min(A,B)$.

Prod: It scales the output fuzzy set.

- **Or method:** Choose max, probor (probabilistic or), or Custom, for a custom operation.

Max: It resolves the statement A OR B, where A and B are limited to the range (0,1), by using the function $\max(A,B)$.

Probor: Probabilistic OR, $y = \text{probor}(x)$ returns the probabilistic OR (also known as the algebraic sum) of the columns of x. if x has two rows such that $x = [a; b]$, then $y = a + b - ab$. If x has only one row, then $y = x$.

- **Implication:** Choose min, prod, or Custom, for a custom operation.

- **Aggregation:** Choose max, sum, probor, or Custom, for a custom operation.

Sum: Simply the sum of each rule's output set.

- **Defuzzification:** For Mamdani-style inference, choose centroid, bisector, mom (middle of maximum), som (smallest of maximum), lom (largest of maximum), or Custom, for a custom operation.

Centroid: Centroid defuzzification returns the center of area under the curve. If you think of the area as a plate of equal density, the centroid is the point along the x axis about which this shape would balance.

Bisector: The bisector is the vertical line that will divide the region into two sub-regions of equal area. It

is sometimes, but not always coincident with the centroid line.

Mom: middle of maximum (the average of the maximum value of the output set).

Som: Smallest of maximum (the smallest of the maximum value of the output set).

Lom: Largest of maximum (the largest of the maximum value of the output set).

V. SIMULATION AND DISCUSSION

FLC controller which has been chosen for evaluating the impact of its parameters is inserted in the DC voltage loop.

A. Parameters of the FLC with the unit weight

This first simulation is considered as a reference and the chosen parameters are below:

And method=min, Or method=max, Implication=min, Aggregation=max, Defuzzification=centroid, Connection=and, Weight=1

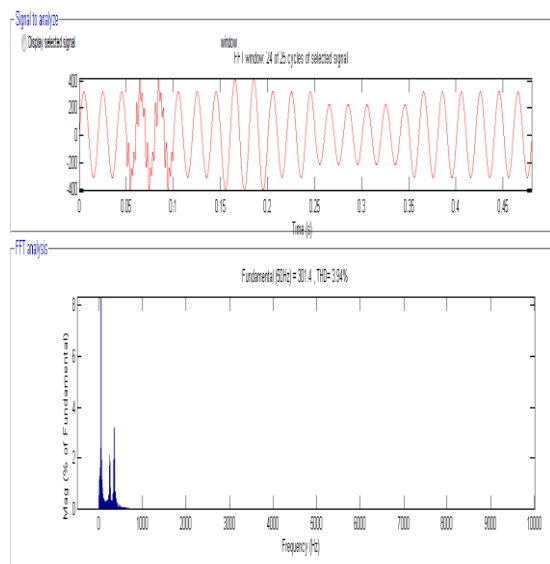


Fig. 4 Source voltage of the phase (a) and its specter

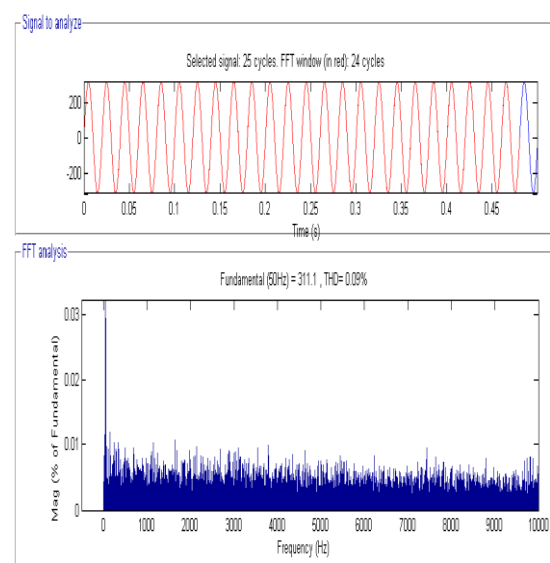


Fig. 5 Load voltage of the phase (a) and its specter

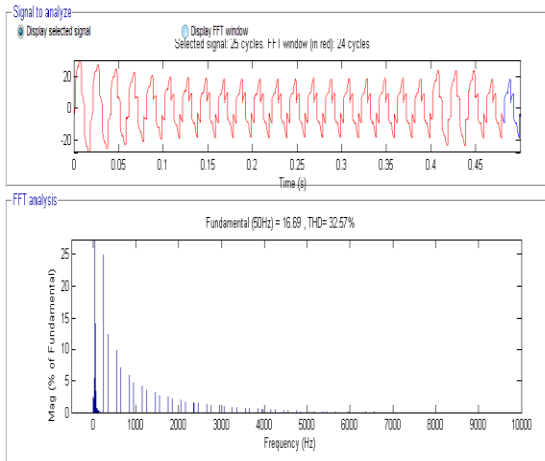


Fig. 6 Load current of the phase (a) and its specter

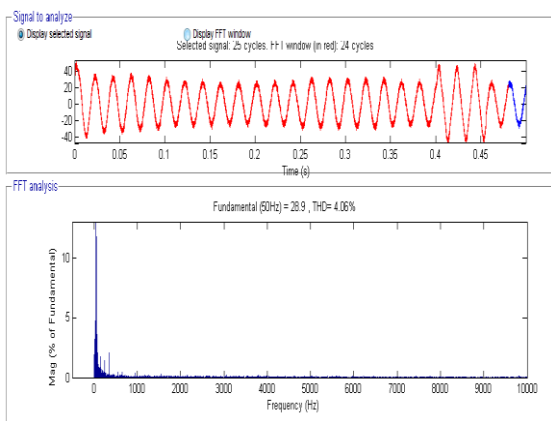


Fig. 7 Source current of the phase (a) and its specter

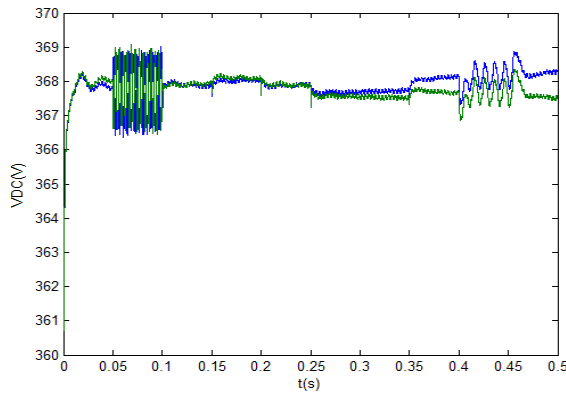


Fig. 8 DC voltage of UPQC

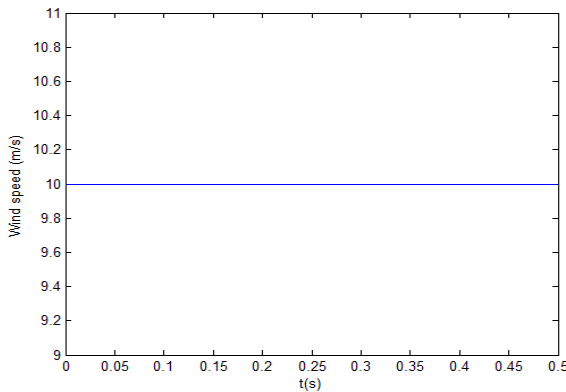


Fig. 9 Wind speed

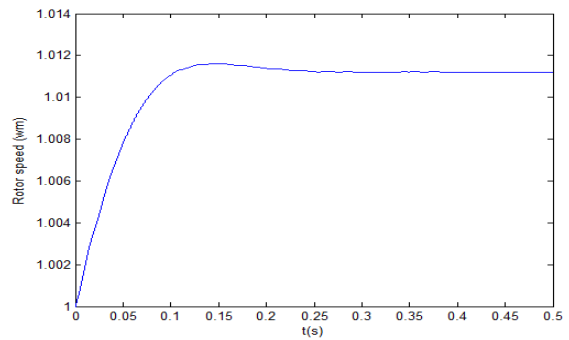


Fig. 9 Rotor speed

The source voltage (Fig. 4) has a THD value of 3.94% and contains three disturbances. The first one is caused by the harmonics 5 and 7 between 0.05 s and 0.1 s, the second represents a swell of 50% of the nominal voltage between 0.15 s and 0.2 s, and the last one is sags voltage of 50% between 0.3 s and 0.35 s. After compensation (Fig. 4), the load voltage is kept at nominal value with a THD value equal to 0.09%. The THD value of the non linear load (Fig. 6) is equal to 32.57%. The source current (Fig. 7) has become sinusoidal with a THD value of 4.06%. Each part of the split capacitor follows its reference voltage (Fig. 8). The impact of the voltage harmonics of the supply voltage is noticeable on the DC voltage between 0.05 s and 0.1 s but without significant impact on the load voltage. The wind speed (Fig. 9) is maintained constant at 10 m/s and the rotor speed too (Fig. 10), due to the control circuit.

B. Parameters of the FLC with the variable weight And method=min, Or method=max, Implication=min Aggregation=max, Defuzzification=centroid, Connection=and, Weight= variable from 0.1 to 1

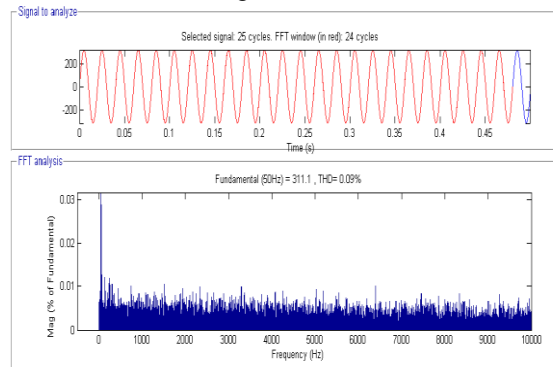


Fig. 11 Load voltage of the phase (a) and its specter

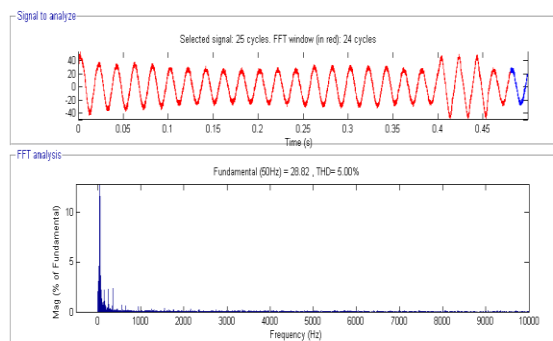


Fig. 12 Source current of the phase (a) and its specter

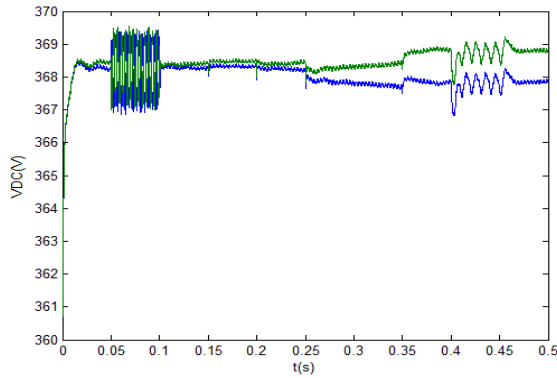


Fig. 13 DC voltage of UPQC

In this case, we have changed the weight value for evaluating its impact during the inference. Generally, the user of the membership fuzzy editor (mfedit) of MATLAB/SIMULINK uses the default value which is equal to 1. The supply and the load are kept at the same conditions as the first simulation. The load voltage (Fig. 11) remains without change with the same value of the THD. Otherwise, we have noticed that the THD value of the source current (Fig. 12) has endured a small change and is equal to 5%. Also, the DC voltage response (Fig. 13) shows a small divergence at the end but without significant influence on the THD value.

C. Parameters of the FLC with new functions
 And method=prob, Or method=probor,
 Implication=min
 Aggregation=probor, Defuzzification=som
 Connection=and, Weight=1

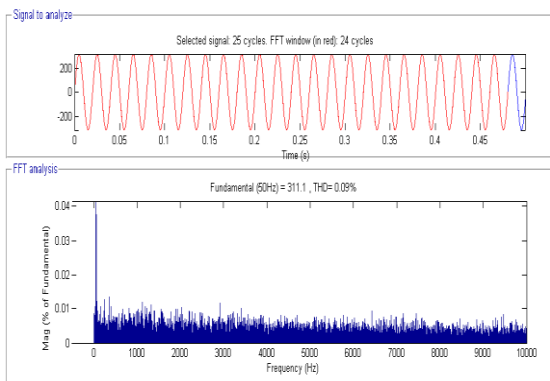


Fig. 13 Load voltage of the phase (a) and its specter

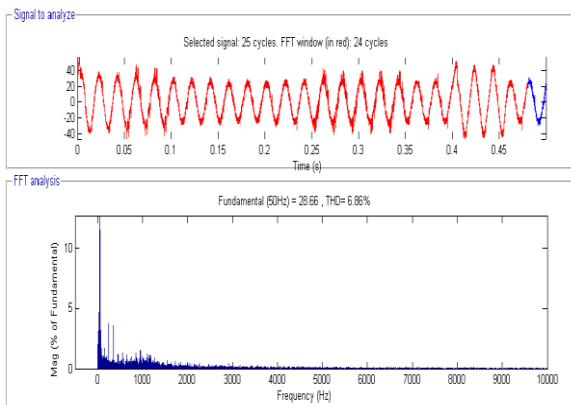


Fig. 15 Load voltage of the phase (a) and its specter

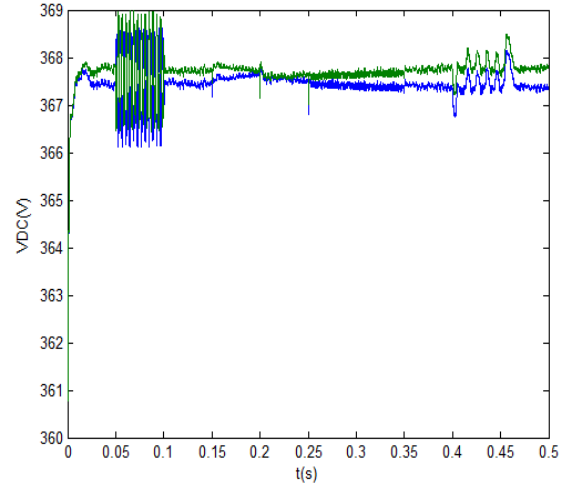


Fig. 16 DC voltage of UPQC

For this last simulation, we have changed the FLC's FIS properties of the DC voltage loop. All characteristics (Figs 14-16) are remained unchanged. The THD value of the source current has endured a small increase.

CONCLUSION

The FLC has become a solution when the classical controller does not satisfy the performance's criteria. Especially, when the non linearity of the model is more important but, the most users of this kind of control use the default parameters of the FIS proprieties. In this paper, we have presented the different functions which are contained in the membership fuzzy editor and also, we have used them for evaluating their impact on the behavior of the FLC which is inserted in the DC voltage loop of the UPQC. The obtained results show that the best choice of these parameters could be a way to improve the system's response such as the variation of the membership function's number or the different functions of the defuzzification. The obtained results in different cases have shown a small change of the behavior of the FLC.

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AN ANALYSIS OF MOBILE BANKING CUSTOMERS FOR A BANK STRATEGY AND POLICY PLANNING

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Abstract-Online banking is increasingly common. Financial institutions deliver online services via various electronic channels, subsequently diminishing the importance of conventional branch networks. This study proposed an integrated data mining and customer behavior scoring model to manage existing mobile banking users in an Iranian bank. This segmentation model was developed to identify groups of customers based on transaction history, recency, frequency, monetary background. It classified mobile banking users into six groups. This study demonstrated that identifying customers by a behavioral scoring facilitates marketing strategy assignment. Then the bank can develop its marketing actions. Thus, the bank can attract more customers, maintain its customers, and keep high customers' satisfaction.

Keywords- Data mining; mobile data, mobile banking; customer segmentation

I. INTRODUCTION

The newly emerging channels of online banking and rapidly increasing penetration rates of mobile phones motivate this study (C. S. Chen, 2013).

The internet has had a significant impact on financial institutions, allowing consumers to access many bank facilities 24 hours a day, while allowing banks to significantly cut their costs. Research has shown that online banking is the cheapest delivery channel for many banking services (Koenig-Lewis, Palmer, & Moll, 2010; Robinson, 2000). A number of studies have identified advantages to bank customers, including cost and time savings as well as spatial independence benefits (Koenig-Lewis et al., 2010).

According to Gartner's prediction of leading trends of 2012 in mobile applications, mobile commerce (m-commerce) remains the most important one. Gartner further forecasts that mobile devices will replace PCs as the main device to access the internet. As for the third quarter of 2012, IPSOS indicated that "The era of Multi-Screen has come, and smartphones account for the purchasing behavior of 65% of mobile device users." According to that report, 66 percent of the smartphone holders in Taiwan access the internet via a smartphone at least once daily; approximately 57 percent of the customers perform mobile searches; and 40 percent of the customers shop via mobile phones (IPSOS, 2012). These statistics reflect vigorous growth in the scale of m-commerce. However, mobile banking remains in its infancy, and international adoption rates demonstrate the strong potential of m-commerce (FRB, 2012). Therefore, data mining for mobile banking is of priority concern for further developing mobile banking services (MBSs) (C. S. Chen, 2013).

Moreover, recent developments in Internet connectivity have led to a renewed interest in Internet banking among specific groups of working individuals. Moreover, with the rapid development of mobile and smart phones, Internet banking has

become more conducive to many more individuals, since they can carry out their banking transactions anywhere and anytime (Govender & Sihlali, 2014; Lee & Chung, 2009). Mobile banking, an extension of Internet banking, provides time independence, convenience, prompt response to customers and cost savings. These benefits serve as an opportunity for banks to increase consumer market through mobile services. Furthermore, mobile technologies, such as smart phones, PDAs, cell phones, and iPads have not only become ubiquitous, but also trendy among young adults (Govender & Sihlali, 2014).

Moreover, in recent years the market orientation has changed to customer centric view. After realizing the importance of simultaneous use of various channels, banking and financial companies are now paying attention to mobile banking especially when it comes to maintenance of customer relationships (Sangle & Awasthi, 2011). The ability to identify customer's most pressing need at a given moment of time is one of the promising propositions of mobile banking. Advanced mobile technologies help banks in offering new services like viewing account details, fund transfer, balance enquiry, loan details, bill payments, enquiry about credit card and demat account and add value to existing ones by disseminating the information at userdefined time and place (Sangle & Awasthi, 2011).

Besides, banking was at the forefront of the service sectors that migrate customers from face-to-face transactions to computer-mediated transactions. With the development of m-commerce, similar expectations have been held out that much banking activity that is currently carried out online through fixed line internet terminals will migrate to mobile devices. The range of services that can be undertaken while mobile is likely to increase, and mobile phones are likely to evolve as ubiquitous payment devices (Koenig-Lewis et al., 2010; Wilcox, 2009).

Market segmentation is one of the most important areas of knowledge-based marketing. In banks, it is

really a challenging task, as data bases are large and multidimensional (Zakrzewska & Murlewski, 2005). Though a number of aspects have been studied for m-commerce, very little is reported regarding the customer segmentation of mobile banking from customer relationship management (CRM) perspective (Wong & Hsu, 2008). The knowledge of the key mobile user segments in financial sector is still lacking. This study attempts to add to the body of literature by data mining in mobile banking services (Sangle & Awasthi, 2011).

In relation to customer-centric business intelligence, banks are usually concerned with the following common Marketing and sales concerns (D. Chen, Sain, & Guo, 2012):

- Who are the most / least valuable customers to the bank? What are the distinct characteristics of them?
- Who are the most / least loyal customers, and how are they characterized?
- What are customers' transaction behavior patterns? Which services have customers purchased together often? Which types of mobile banking users are more likely to respond to a certain promotion mailing?
- What are the sales patterns in terms of various perspectives such as services, regions and time (weekly, monthly, quarterly, yearly and seasonally), and so on? and
- What are the user segments in terms of various perspectives (D. Chen et al., 2012)?

In order to address these marketing concerns, data mining techniques have been widely adopted, coupled with a set of well-known business metrics about customers' profitability and values, for instance, the recency, frequency and monetary (RFM) model, and the customer life value model (D. Chen et al., 2012).

In this article a case study of using data mining techniques in customer-centric business intelligence for a bank was presented. The main purpose of this analysis is to help the bank better understand its mobile banking customers and therefore conduct customer-centric marketing more effectively. On the basis of a new segmentation model, customers of the bank have been segmented into various meaningful groups. Accordingly, a set of recommendations was provided to the bank on customer-centric marketing (D. Chen et al., 2012).

II. LITERATURE SURVEY

Banks operate in a competitive environment facing challenges in customer acquisition and service costs. In such an environment, the understanding and prediction of customer behavior in usage of services is becoming an important subject. The banks' intention is to shift customers to technology enabled self-service channels like ATMs, internet banking

and more recently onto mobile banking services. Customers, these days are more and more pressed for time and they seek a channel that offers them convenience of anytime, anywhere banking and mobile banking services fits the bill very well. In Iran, mobile banking services seem to be high on priority for banks (Thakur, 2014).

Particularly in Iran, banking services on mobile banking were launched few years ago yet the usage of such services has not reached the desired level. Therefore, it becomes more important to look for the customer segments. The studies conducted on bank information technology adoption render insufficient information about customer segmentation (Sangle & Awasthi, 2011). In this regard the current study tends to emphasize customer data mining framework and identify the mobile user segments.

2.1. Mobile Banking

While the use of branch-based banking is still very popular, banks have other ways of providing customers with financial management services and one of them is mobile banking (Govender & Sihlali, 2014). The mobile phone as a channel for service consumption offers enormous potential since today, a mobile phone is an integral part of customers' life and a growing number of these devices are also equipped with internet connection. Currently mobile banking services enable consumers, for example, to request their account balance and the latest transactions of their accounts, to transfer funds between accounts, to make buy and sell orders for the stock exchange and to receive portfolio and price information (Laukkanen, 2007). Hence it is necessary to investigate mobile banking customer segments.

2.2. Cross-selling Analysis

The rationale for cross-selling, defined in the introduction as "the strategy of selling other products to a customer who has already purchased a product from the vendor" is not only to "increase the customer's reliance on the company and decrease the likelihood of switching to another provider" but also to exert a generally positive influence on the relationship with the customer, strengthening the link between provider and user (Kamakura, Wedel, De Rosa, & Mazzon, 2003). Increasing product holding leads to an increased number of connection points with customers, as well as increasing the switching costs they would face if they decided to take their custom elsewhere. Increased product holding also creates a situation in which the company can get to know its customers better through a greater understanding of buying patterns and preferences. This, in turn, puts it in a better position to develop offerings that meet customer needs. Consequently, it is argued that cross-selling increases the total value of a customer over the lifetime of the

relationship (Ansell, Harrison, & Archibald, 2007; Kamakura et al., 2003).

Cross-selling, and consequently cross-buying, is receiving considerable attention in both research and management in the financial services industry. Denoting to terms such as “bancassurance” and “allfinanz”, i.e. the sales of insurance products by banks, and on the other hand “assurfinance”, i.e. the sales of financial products by insurance companies, changes in the market such as deregulation and increasing competition have driven the once traditional financial service providers towards increasing provision of integrated financial services, that is, offering their customers a seamless service of banking, investment and insurance products (Mäenpää, 2012; Van den Berghe & Verweire, 2001).

2.3. Bank customer segmentation

Market segmentation has become one of the most dominant concepts in both marketing theory and practice. In banking industry, like any other service industries, segmentation is considered as a major way of operationalizing the marketing concept, and providing guidelines for a bank’s marketing (Edris, 1997). As theory, market segmentation is the process of dividing a market into distinct groups of individuals, or organizations, who share one or more similar responses to some elements of the marketing mix. The segmentation process calls for dividing the total market into homogeneous segments, selecting the target segments, and creating separate marketing programs to meet the needs and wants of these selected segments (Edris, 1997).

The identification of segments allows the evaluation and refinement of a bank’s marketing strategy. The effectiveness of the segmentation process and strategy depends on identifying segments that are measurable, accessible, substantial, and actionable (Edris, 1997).

2.4. CLV and RFM Analysis

Customer segmentation is used in different settings, for instance, using customer segmentation for estimating customer future value as a part of customer lifetime value (CLV) in banking scope (Khobzi, Akhondzadeh-Noughabi, & Minaei-Bidgoli, 2014). Generally, customer segmentation is often used to obtain more details about different customers in banking scope. Actually, according to these studies diverse groups of banks’ customers are identified by segmenting based on customers’ financial transactions (Khobzi et al., 2014).

RFM analysis is a widely used method that identifies customer behavior and represents customer behavior characteristics, and it stands for the words: Recency, Frequency, and Monetary. Generally, these parameters are defined as follows (Khobzi et al., 2014):

- Recency: The interval between the purchase and the time of analysis.
- Frequency: The number of purchases within a certain period.
- Monetary: The amount of money spent during a certain period.

These definitions are adaptable and can vary in different cases. In recent years, several researchers tried to extend the concept of RFM analysis, but there is lack of studies that analyze the customer segments and RFM analysis focusing banks over the mobile banking platform. Thus, although the increasing competitiveness in mobile banking is motivating an exponential growth in the number of studies, there is a call for studies that will help us to understand how customer behavior are formed in the mobile banking business in greater detail.

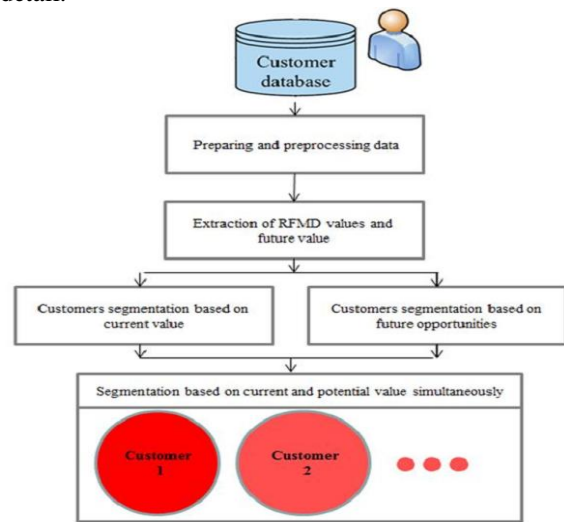


Fig. 1. Research methodology using RFMD variables and potential value.

Moreover, the rapid development of data mining methods enables using large data bases of customer data to extract the knowledge, supporting marketing decision process. As the ability to acquire new customers and retain existing is crucial, especially in the finance marketplace, the possibility of customer segmentation by obtaining their information on unknown hidden patterns has a major significance. Until now only few papers present using of data mining techniques in banks. In our work, we consider application of a new RFM segmentation algorithm in this area (Zakrzewska & Murlewski, 2005).

III. METHODOLOGY

In this study, numbers of mobile banking users of a major bank in Iran were studied. These user demographics were shown in table I. Additionally, bank customer table was shown in table II. The proposed methodology utilized a new segmentation methodology, as shown in Fig. 1. In this work, customer priority number (CPN) or RFMD as a new model of RFM, was introduced for first time. It is the

product of the recency (R), frequency (F), average transaction amount or monetary (M) and customer deposit (D) ratings: $RFMD = R \times F \times M \times D$
 The rationale of the proposed approach is that if customers have had similar purchasing behavior, then

they are very likely also to have similar RFMD values. RFMD values were used to cluster customers into groups with similar RFMD values. The scaling of R-F-M-D attributes was shown in table III.

TABLE I. Demographics of mobile banking users

Education	Percent (%)	Occupation	Percent (%)	Gender	Percent (%)	Age	Percent (%)
High school	0.56	Employee	0.364	Male	0.804	Young	0.36
College	0.34	Business	0.397	Female	0.196	Middle	0.578
Master and above	0.1	Engineer	0.054			Old	0.062
		Manager	0.016				
		Student	0.07				
		Physician	0.07				
		Faculty	0.01				
		Others	0.019				

TABLE II. Customer table.

Field Name	Data Type	Description	Value set
ID	Text	Customer ID code	-
Acct-NO	Text	Customer account number	-
Birth-Date	Text	Below 30; 30-40; 40-60; 60 and above	{Y, M, O}
Sex-code	Text	Gender	{F, M}
Marital_Status	Yes/No	-	{Y, N}
Education	Text	High school and below; college; master and above	-
Occupation	Text	Manager; employee of company; student; others	-
Operator-Network	Text	IR-TCI; MTN-Irancell; Talya	{I, M, T}
Service Type	Text	e.g. Payments, Transfers, Payments & Transfers	-
Open-Date	Date/Time	Account opening date	-
Amount	Number	-	-
Transaction-Date	Date/Time	-	-
Balance	Number	Account status	-

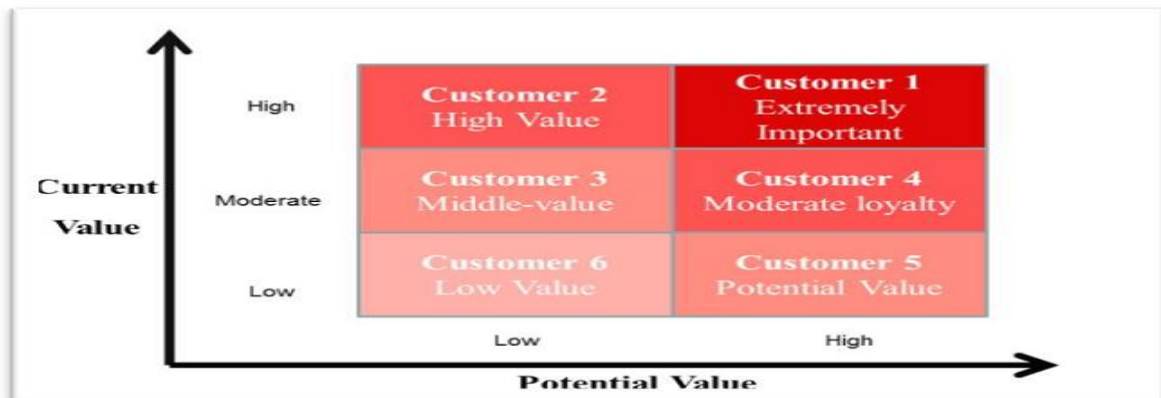


Fig. 2. Customer segmentation result based on CLV

Fig. 3. The partial data of C-Bank dataset

TABLE VI. Segmentation results

ID	RFMD	Current Value	Potential Value	Customer Type or Segment	Segment	Marketing Strategy
0017805	108	High	High	Customer 1	Extremely important	Relationship management
0017760	12	Low	High	Customer 5	Potential value	Retention
0017832	24	Low	Low	Customer 6	Low value	Growing

TABLE III. The scaling of R-F-M-D attributes

Field Name	Description	Value set
ID	-	-
Recency	Below 15; 16~30; 31 and above (day)	{3, 2, 1}
Transaction Frequency	Below 5; 5~20; 21 and above (in a fiscal year)	{1, 2, 3}
Transaction amount average	NT\$100 and below; 100~1,000; 1,001~3,000; 3,001 and above	{1, 2, 3, 4}
Deposit Average	NT\$1,000 and below; 1,001~7,000; 7,001~20,000; 20,001 and above	{1, 2, 3, 4}

TABLE V. RFMD values for each customer

ID	Acct-NO	Recency	Transaction Frequency	Transaction amount average	Deposit Average	R	F	M	D
.
0017805	0027864	10	30	1200	41000	3	3	3	4
0017760	0027866	8	4	450	5120	3	1	2	2
0017832	0027942	25	12	150	15000	2	2	2	3
.

RFMD refers to the customer current value. It calculated for each stored customer data (Table II). RFMD or CPN ranking was illustrated in table IV. The rankings given are normally scored on a scale

of 1-4. Therefore, CPN would be between 1 and 144. After the case priority number (CPN) was computed, customer current value could be determined. After RFMD computation, potential value of customer

based on future opportunities should be estimated. The CPN and potential value of customer are main elements for customer segmentation (Fig. 2).

TABLE IV. Suggested CPN table for customer current value

Segment	Value
High value	81~144
Moderate	36~80
Low	1~35

IV. CASE STUDY

This work considered a bank customer records to conduct empirical research (Fig. 3). Three customers were selected to show methodology effectiveness. The real data of selected customers and related R, F, M, and Ds were shown in table V. RFMDs were computed and customer potential values were illustrated in table V. Meanwhile customer type and its marketing strategy were derived (Table VI).

V. MANAGERIAL IMPLICATIONS

The bank's marketing and business manager, bank branch manager, or analysts can employ the segments to:

- Better understand customers. The bank can track changes to customers' life styles. Better customer knowledge and understanding are the cornerstones of effective and profitable customer management (Zuccaro & Savard, 2010).
- Enhance the value of segmentation systems. Proactive segmentation systems are enhanced when they are updated regularly. This means that both demographic and transaction data are integrated into an ongoing process of customer segment management. Customer segments possess the built-in capacity to integrate demographic and transaction data. Up-to-date and relevant segmentation system provide the bank with invaluable data to plan new service offerings, predict customer reaction and determine profit levels on a segment-by-segment basis. Segmentation system enhances the bank's capacity to employ customer knowledge in a more strategically effective manner (Zuccaro & Savard, 2010).
- Improve marketing effectiveness. Without a sound segmentation system a bank would not be able to perform valid and reliable customer prospecting which in turn would seriously undermine the effectiveness and profitability of customer targeting. The starting point for serious customer prospecting and targeting is the bank's customer data and transaction database. It provides the analyst with invaluable behavioral information (use of mobile banking by each customer). In addition, the database will contain rudimentary socio-

demographic data such as the customer's age, sex, marital status and some employment information. Customer prospecting and targeting could be undertaken employing such data. Customers would be placed in groups. Many organizations have realized that by enhancing their customer database they can significantly improve their customer prospecting and increase the lift of customer targeting strategies. Thus, segmentation is designed to exploit the potential of the bank's customer database. Once a specific customer segment generated by RFMD segmentation has been identified, it becomes relatively simple to identify the customer prospects and target them with the appropriate strategy and promotional tools (Zuccaro & Savard, 2010).

- Develop effective communications. In the age of segmentation, developing an effective communication strategy is not a simple task. The nature and variety of potential communication messages and media to transmit the messages has grown exponentially during the last two decades. In addition, most organizations, including banks, are abandoning traditional communication media such as television and radio and opting for more specialized vehicles such as the web. Segmentation provides the bank with a richer set of segments that can be described with an impressive level of detail. The refined segments along with detailed financial life style of its members allow the bank to design tailor-made communication strategies (Zuccaro & Savard, 2010).

CONCLUSION

Mobile phone handsets, which were initially used almost exclusively for voice calls are now often used to transmit data and undertake commercial transactions. In recent years, mobile phones have become very popular with a penetration rate in many of states of Iran. The term m-commerce has been widely used to describe a subset of e-commerce and refers to transactions with monetary value that are conducted via mobile devices (Koenig-Lewis et al., 2010).

Iranian banks today face intense competition inside and outside Iran. This in turn has forced these banks to be more oriented towards their customers. The main focus of this study was on the customer segmentation. Banks which are marketing-oriented are not only required to be aware of the needs of their customers, but they should be able to satisfy effectively the needs of each identified customer segment. This study provides evidence that segmentation of the customers is of great importance to banks in order to identify the behavior of each segment and provide certain marketing actions that best suit these behaviors. The results of this study provide a practical approach to Iranian banks that

would help in determining the true segments of mobile banking customers (Edris, 1997).

Furthermore, one of the important factors for the success of a bank industry is to monitor their customers' behavior. The bank needs to know its customers' behavior to find interesting ones to attract more transactions which results in the growth of its income and assets.

The RFM analysis is an approach for extracting behavior of customers and is a basis for marketing and CRM, but it is not aligned enough for banking context (Bizhani & Tarokh, 2011). So, this study introduced new RFM model to improve understanding of bank customers.

Furthermore, this paper presented a framework of segmentation by applying it to the customers of one of Iran's major banks. Also, this paper presented a synthesized example of segmentation in the banking sector. The proposed model improved current understanding of mobile banking customers. Meanwhile, from a practical perspective, insights provided by the study can help mobile banking managers to manage mobile users' behavior.

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ADVANTAGE OF MAKE-TO-STOCK STRATEGY BASED ON LINEAR MIXED-EFFECT MODEL

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Abstract- In the past few decades, demand forecasting becomes relatively difficult because of the rapid changes of world economic environment. In this research, the make-to-stock (MTS) production strategy is applied as an illustration to explain that forecasting plays an essential role in business management. We also suggest that linear mixed-effect (LME) model could be used as a tool for prediction and against environment complexity. Data analysis is based on a real data of order quantity demand from an international display company operating in the industry field, and the company needs accurate demand forecasting before adopting MTS strategy. The forecasting result from LME model is compared to the common used approaches, times series model, exponential smoothing and linear model. The LME model has the smallest average prediction errors. Furthermore, multiple items in the data are regarded as a random effect in the LME model, so that the demands of items can be predicted simultaneously by using one LME model. However, the other approaches need to split the data into different item categories, and predict the item demand by establishing model for each item. This feature also demonstrates the practicability of the LME model in real business operation.

Index Terms- Forecasting, linear mixed-effect model, make-to-stock, order demand, production strategy

I. INTRODUCTION

Demand forecasting is crucial for supply chain management. Production planning, inventory management, and manufacturing scheduling are typically formulated according to short- and long-term expected demand [1]. To reduce the occurrence of delivery delays caused by the “crowding out” effect of manufacturing processes, contemporary enterprises have gradually changed their production patterns from make-to-order (MTO) to make-to-stock (MTS), and increasingly fewer enterprises are using the MTO production strategy [2 , 3]. The MTO production involves commencing product production only after the customer places the order. The MTS production pattern entails a stocking-up production, in which a company manufactures products and stores them in inventory before customer orders are received. Subsequently, the company sells its stock as customer places orders. If a company receives orders requesting a high mix of products but in low volumes, it must be capable of forecasting their order demand accurately before attempting an MTS production strategy. Accordingly, the advantages of the MTS production strategy—including quick delivery, arranging a long-term manufacturing schedule, reducing the stock levels, and stabilizing product prices—can be realized. Worldwide, variation in customer demand has forced many manufacturers to adopt a high-mix low-volume production model. However, this type of enterprise is not as efficient as a low-mix high-volume enterprise. Therefore, determining how high-mix low-volume enterprises can enhance their business operation performance urgently requires a solution. Hence, accurately forecasting order demand is a fundamental to successfully applying the MTS

production strategy to a high-mix low-volume business operation model. Because inaccurate demand forecast is a concern for high-mix low-volume enterprises, the MTO production strategy is typically adopted. However, this production pattern increases financial risks and requires a long delivery time, making centralized production difficult, which subjects production lines to frequent changes, resulting in high operating costs and low product quality. Complex operations are the primary cause of human error and low job satisfaction. Therefore, if the inefficiency of the high-mix low-volume business operation model cannot be solved, then, despite a high business revenue, business operation costs would increase rapidly, product quality would reduce, and employee job satisfaction and customer satisfaction would decrease, which result in that business development would stagnate. Therefore, the forecasting method proposed in this study can provide a crucial basis for transitioning from using the MTO to the MTS production, and may offer a viable solution for improving the business operation performance of high-mix low-volume enterprises. The application and improvement of the proposed forecasting method can assist researchers with understanding the characteristics of business operations and construct related business operation models. Forecasting ability depends on crucial information and reliable forecasting methods. In recent years, demand forecasting has become increasingly complex, primarily because the global economic environment has gradually changed. The underlying reasons for this change can be explained in terms of the following four dimensions: volatility, uncertainty, complexity, and ambiguity (VUCA) [4 , 5 , 6], all of which have been shown to influence

demand forecasting [7]. Volatility means that new products are rapidly developed, product lifecycles are shortened, customer preferences change suddenly, and organizations are frequently restructured; consequently, historical data diminishes in value. Uncertainty refers to unknown factors that cause sudden shifts in demand, and these factors are generally regarded as outliers or interferences. Complexity means that the interaction of these influential factors cannot be modelled easily, and ambiguity refers to fuzzy events and situations that cannot be quantifiably defined, leading to the loss of key influential factors. In summary, according to the influence of economics on demand forecasting, developing a reliable forecasting method requires analyzing whether historical data can contribute to demand forecasting, and whether the effects of influential factors can be identified. To meet the requirements of modern forecasting methodologies, this study proposed using linear mixed-effect models to perform forecasting. Linear mixed-effect models have been extensively developed and widely applied in various fields. However, no study has used this model to forecasting in business operation. Linear mixed-effect models are characterized by the inclusion of temporal factors and explanatory variables and the analysis of their significance. Accordingly, crucial influential factors can be identified to forecast demand. These characteristics fulfill the requirements of modern forecasting methodologies and can be used as the basis for companies to improve their operation efficiency and to develop competitive advantages. The following sections explore the influences of the MTO and MTS production strategies on business operation as well as the role of forecasting in the MTS strategy, provides a review of the literature on forecasting methodologies, and summarizes the strengths and weaknesses of commonly used forecasting methods. In addition, the proposed linear mixed-effect model as well as a method for model parameter estimation are introduced. Subsequently, the order demand of a manufacturer in central Taiwan is forecasted using product type as a crucial explanatory variable. Specifically, the linear mixed-effect model is applied to forecast the order demand for 20 individual product types. A 1-year forecast of monthly demand is reported, and three types of forecast errors are used to assess the forecasting ability of the model. The results show that the forecasting ability of the linear mixed-effect model in an empirical analysis is superior to those of a linear forecasting model, exponential smoothing method, and time-series forecasting method.

II. LITERATURE REVIEW

A. Influences of the MTO and MTS on Business Operations

Modern production strategies primarily involve two

main production patterns: the MTO (based on customer orders), and the MTS (based on production capacity) [8]. From the perspective of customers, one competitive advantage of the MTS production is short delivery time and quick response [9]. Therefore, identifying the types of products that are specifically suitable for the MTS production pattern or both MTS and MTO patterns is a favored research topic in management science [8].

Regarding the influences of the MTO and MTS production strategies on business operations, Hendry and Kingsman [10] showed that the MTS and MTO production strategies are mostly used for manufacturing standard and customized products, respectively. Regarding the attributes of orders, order demand for MTS products is generally predictable, whereas that for MTO products is irregular and unpredictable. Concerning production planning, MTS production lines operate according to forecast results, and the production line schedule can be adjusted easily. However, the schedule of MTO production lines is determined based on recent order demand, and long-term manufacturing schedules are difficult to determine. In terms of product delivery, enterprises that adopt the MTS production strategy can ensure rapid product delivery, thus maintaining high customer satisfaction. The MTO production pattern requires long delivery times, and enterprises adopting this strategy must communicate with customers to achieve consensus regarding product delivery time. Concerning product price, compared with prices of products produced adopting the MTO strategy, the prices of MTS-produced products are relatively more stable. Soman, van Donk, and Gaalman [8] indicated that the MTO production pattern is effective for handling orders requesting high-mix customized products; the production planning for the MTO strategy must prioritize meeting order demands, while production effectiveness is determined according to crucial elements in the orders (e.g., the expected delivery volume and number of delayed delivery days). The goal of a company that manufactures MTO products is to shorten product delivery times; production efficiency emphasizes the importance of capability planning, orders that are lost due to problems with manufacturing processes, and on-time product delivery. By contrast, the MTS production pattern is effective for handling uniform product specifications and less customized products, where production planning is determined based on product demand forecasting and production effectiveness is production-oriented. Therefore, the goal of a company manufacturing MTS products is to enhance product availability, and its production efficiency emphasizes the importance of inventory policy, finished goods inventory, one-off or batch production, and accurate demand forecast. Rajagopalan [11] indicated that inventory costs are slightly higher for the MTS strategy than for the MTO strategy, particularly for one-off and batch production.

In summary, the MTS strategy relies heavily on the accuracy of product demand forecasting. Because of accurate forecasting, the advantages of the MTS production strategy, including short delivery time, manageable long-term manufacturing schedule, and stable product prices, can be realized. In addition, accurate forecasting can optimize inventory levels; therefore, companies applying the MTS strategy can effectively control inventory costs. Some researchers have explored the inventory policies and material control mechanisms in MTO production [12]. The forecasting method proposed in this study provides a relatively accurate basis for forecasting random customer orders (demand) for MTS production.

B. Forecasting Methodology

Two main types of forecasting methodology exist: (1) statistical methods; and (2) data mining and machine learning [13]. Both types of forecasting methodology are aimed at identifying the relationship between influential factors (independent variables) and research variables (dependent variables), and identifying the effects of the influential factors on research variables [7]. These two methodologies involve distinct approaches to interpreting analysis models. The statistical methodology is based on the data derived from a specific mathematical model as well as unobservable errors. The machine-learning methodology avoids fitting data to a specific model and develops algorithms that are suitable for various types of data. These two methodologies differ in their strengths and characteristics [13]. The statistical methodology uses the probability distribution of errors to infer the significance of the influential factors in a model. The reliability of inferences correlates positively with the mathematical model. The machine learning methodology uses the size of forecast errors as a basis for selecting the optimal forecasting model.

Several typical forecasting methods are introduced as follows, the characteristics of which are shown in Table 1. The exponential smoothing method was proposed by Holt [14] and the statistical theoretical foundation for this method was established by Muth [15]. This method involves using a demand observation and predictive value in the current period to determine the predictive value for the subsequent period by using weighted mean. To date, the exponential smoothing method has been widely applied to forecast demand under the bullwhip effect [16] and to plan inventory control strategies [17]. Moreover, the methodology for exponential smoothing has been developed in recent years into one that incorporates the effect of influential factors on the accuracy of demand forecasts [7, 18, 19]. Wang [19] used a model selection method where crucial influential factors were included in the selected model, and nonsignificant factors were removed to avoid over-fitting the model.

Time-series model was first developed in the

nineteenth century, and past studies related to such model were then systematically compiled by Box and Jenkins [20] into a book. A time-series autoregressive integrated moving average (ARIMA) model integrates an autoregressive process and moving average process after obtaining a finite difference from time-series data. The ARIMA model is used to estimate the correlations parameter between the time points of observed values, and the estimated parameter

Table 1. CHARACTERISTICS OF FORECASTING METHODS . (○: YES ; △: YES FOLLOWING MODIFICATION BY OTHER STUDIES

Forecasting method	Can handle temporal data	Can include influential factors	Analyzing the importance of influential factors (e.g., <i>p</i> value)
Linear mixed-effect model	○	○	○
Exponential smoothing method	○	△	△
ARMA	○	△	△
Linear model	△	○	○

values can then be used for forecasting. Subsequently, Box and Tiao [21] added other time-series influential factor to the ARIMA model. Pankratz [22] called this model the dynamic regression model.

Linear regression models are a type of linear model that are most frequently mentioned in statistical analyses. Linear models assume that research variables and influential factors are linearly related, and thus can be used to explore the effect of influential factors on research variables. Furthermore, linear models assume that observation values are mutually independent; thus, this model is applicable for analyzing data containing mutually independent observation values. If linear models are used to analyze time-correlated data, i.e., the observation values being correlated over time, then unbiased but invalid model coefficient estimators can be obtained. Consequently, the standard errors of the model coefficient estimators would be incorrect, and problems regarding statistical testing within the models arise, such as whether the model coefficients are significantly greater than 0, whether the models exhibit explanatory power, and whether the predictive intervals are reliable in forecast analysis [23, 24].

Linear mixed-effect models can be considered as an extension of linear models. The linear mixed-effect models add random effects to linear models with fixed effects. Hence, a model that has both fixed and random effects is called a linear mixed-effect model. Linear mixed-effect models are typically used to describe the relationship between research variables and categorical factors with correlated observation values. A characteristic of the mixed-effect models is that observation values at the same categorical level

have identical random effect values for dependent variables; observation values at different levels have distinct values of random effect. This characteristic explains the correlation between observation values at an identical level. Therefore, linear mixed-effect models differ considerably from linear models. The mixed-effect model can be applied to data where observation values are correlated (e.g., longitudinal data, repeated measures data, and multilevel data). However, linear models can be applied only to data where the observation values are mutually independent. In industrial operations, the pattern of data observations is often time-correlated. For example, when forecasting monthly product demand or monthly inventory levels, the observation values are correlated over time. Under such circumstances, the linear mixed-effect model is more accurate than linear models for identifying statistically significant factors.

In the past 2 years, the linear mixed-effect model has been broadly applied in various fields, such as the timber industry [25], medicine [26, 27], and ecology [28], to identify crucial influential factors. In addition, numerous studies have established models for forecasting [29, 30]. However, in industrial engineering and management science [24, 31, 32, 33], no study has used the linear mixed-effect model to make predictions by using time-correlated data or to identify key influential factors. Therefore, in this study, a linear mixed-effect model was applied to business operations to analyze the importance of influential factors, and to forecast product demand; in addition, the performance of the linear mixed-effect model was compared with that of other methods, which are the research contributions of this study.

III. LINEAR MIXED-EFFECT MODEL

According to parameter attributes, two types of effect exist in a linear mixed-effect model: fixed and random effects [34, 35]. In a linear model, the parameters are all fixed values and therefore its corresponding covariates are referred to as fixed-effect parameters. The fixed effect describes the true value of the coefficient for an entire population, or the true value of the coefficient for a factor that can be repeatedly tested under identical conditions. If a factor in a model exhibits a random effect, then the factor is sampled from an entire population. The random effect is a coefficient of the factor; moreover, the coefficient is a random variable and not a fixed value. The following section introduces the linear mixed-effect model developed by Laird and Ware [36] and the estimation of model parameters, and describes how the research variables are forecasted.

A. Linear Mixed-Effect Model

In contrast to a multilevel model, a single-level linear mixed-effect model [36] was employed in this study. The multilevel model differs from the single-level

model in terms of the covariance matrix of the observation values. The single-level model involves only one level, whereas the multilevel model involves at least two levels. The covariance matrix of the multilevel model is more complex than that of the single-level model. In practice, whether using a single-level or multilevel model is more appropriate depends on the data structure of the observation values. Although the covariance matrices of the two models differ, the observation values of the various groups at a fixed level are independent of each other, and the within-group observation values are intercorrelated. In the multilevel model, a group at one hierarchy level becomes the next level of the hierarchy.

The single-level linear mixed-effect model developed by Laird and Ware [36] is expressed as follows:

$$\mathbf{y}_i = \mathbf{X}_i \boldsymbol{\beta} + \mathbf{Z}_i \mathbf{b}_i + \boldsymbol{\varepsilon}_i, \quad i = 1, \dots, M \quad (1)$$

$$\mathbf{b}_i \square \mathcal{N}(\mathbf{0}, \boldsymbol{\Psi}), \quad \boldsymbol{\varepsilon}_i \square \mathcal{N}(\mathbf{0}, \boldsymbol{\Lambda}_i), \quad (2)$$

where \mathbf{b}_i is a matrix that is independent of $\boldsymbol{\varepsilon}_i$ (index i denotes the i th group at a single level), \mathbf{y}_i contains n_i observation values for the i th group, M denotes the number of groups, $\boldsymbol{\beta}$ denotes a p -dimensional vector for the fixed effect, \mathbf{b}_i denotes a q -dimensional vector for the random effect, \mathbf{X}_i denotes an $n_i \times p$ covariance matrix for the fixed effect, \mathbf{Z}_i is an $n_i \times q$ covariance matrix for the random effect, and $\boldsymbol{\varepsilon}_i$ denotes an n_i -dimensional within-group random error term. The variable $\boldsymbol{\varepsilon}_i$ obeys a multivariate normal distribution with an expected value of 0 and a covariance matrix of $\boldsymbol{\Lambda}_i$, and \mathbf{b}_i obeys a multivariate normal distribution with an expected value of 0 and a covariance matrix of $\boldsymbol{\Psi}$. The model assumes that $\boldsymbol{\varepsilon}_i$ and $\boldsymbol{\varepsilon}_j$ are mutually independent ($i \neq j$); in addition, $\boldsymbol{\varepsilon}_i$ and \mathbf{b}_i are mutually independent. Therefore, considering Models (1) and (2), the covariance matrix of the within-group observation values \mathbf{y}_i is expressed as follows:

$$\mathbf{V}_i \equiv \text{Var}(\mathbf{y}_i) = \text{Var}(\mathbf{Z}_i \mathbf{b}_i) + \text{Var}(\boldsymbol{\varepsilon}_i) = \mathbf{Z}_i \boldsymbol{\Psi} \mathbf{Z}_i^T + \boldsymbol{\Lambda}_i \quad (1)$$

where the nondiagonal elements of \mathbf{V}_i are not required to be 0. Therefore, according to (3), Models (1) and (2) allow the existence of the correlation between observation values within a group. This is a major difference that the two models have with the linear model.

B. Estimation of the Model Parameters

This section introduces estimation methods that adopt the linear mixed-effect model: the maximum likelihood (ML) and restricted ML (REML) estimation methods. Regarding the ML method, the

estimates of ML estimators are those that reach the maximum value of ML functions. By comparison, the REML method is aimed at identifying the estimators that exhibit unbiased characteristics. Therefore, estimators obtained using the REML method are unbiased, whereas those derived using the ML method could feature either biased or unbiased property. Therefore, most researchers prefer the REML method [34, 35]. We introduce the estimation procedures for both of these estimation methods, although only the REML method was used in this study.

First, the model β coefficient and covariance matrix of observation values \mathbf{V}_i are estimated as follows. In Models (1) and (2), the expected values of \mathbf{b}_i and $\boldsymbol{\varepsilon}_i$ are assumed to be 0; thus, the expected value of y_i is $\mathbf{X}_i\beta$ (i.e., $E(\mathbf{y}_i) = \mathbf{X}_i\beta$). Because the covariance matrix of y_i is \mathbf{V}_i (i.e., $\text{Var}(\mathbf{y}_i) = \mathbf{V}_i$) and because \mathbf{b}_i and $\boldsymbol{\varepsilon}_i$ obey an independent multivariate normal distribution, the marginal distribution of y_i is a multivariate normal distribution expressed as follows:

$$\mathbf{y}_i \square N(\mathbf{X}_i\beta, \mathbf{V}_i)$$

The ML function is expressed as follows:

$$L(\beta, \theta) = \prod_{i=1}^M (2\pi)^{\frac{-n_i}{2}} \det(\mathbf{V}_i)^{-\frac{1}{2}} \times \exp\left\{-\frac{1}{2}(\mathbf{y}_i - \mathbf{X}_i\beta)^T \mathbf{V}_i^{-1}(\mathbf{y}_i - \mathbf{X}_i\beta)\right\}$$

where θ denotes the set of $\mathbf{V}_1, \dots, \mathbf{V}_M$. To facilitate differentiation, the natural logarithm of the ML function is used instead of the ML function to evaluate the ML and REML estimators, and define $l(\beta, \theta) = \ln L(\beta, \theta)$.

ML estimation method The ML estimates of β and θ

are the values that maximize $l(\beta, \theta)$ and thus are also the values that maximize $L(\beta, \theta)$. Calculating the maximum value of $l(\beta, \theta)$ is challenging. Typically,

let $\theta = \hat{\theta}$, and evaluate the value of β such that it

maximizes $l_{\theta=\hat{\theta}}(\beta, \theta)$. Subsequently, let $\beta = \hat{\beta}$, and calculate the value of θ such that it maximizes the value of $l_{\beta=\hat{\beta}}(\beta, \theta)$. This process is iterated until the

change in $\hat{\beta}$ and $\hat{\theta}$ is within a tolerance error (i.e., the $\hat{\beta}$ and $\hat{\theta}$ values converge).

Specifically, we first let θ be $\hat{\theta}$ (equivalent to letting \mathbf{V}_i be $\hat{\mathbf{V}}_i$, $i = 1, \dots, M$). Under these conditions, \mathbf{y}_i obeys $N(\mathbf{X}_i\beta, \hat{\mathbf{V}}_i)$. An analytical solution for β can be obtained by using the generalized least squares method.

$$\hat{\beta} = \left(\sum_i \mathbf{X}_i^T \hat{\mathbf{V}}_i^{-1} \mathbf{X}_i\right)^{-1} \sum_i \mathbf{X}_i^T \hat{\mathbf{V}}_i^{-1} \mathbf{y}_i \quad (4)$$

Accordingly, $l_{\theta=\hat{\theta}}(\beta, \theta)$ is the maximum value. Next,

fix β in $l(\beta, \theta)$ as $\hat{\beta}$, denoted by $l_{\beta=\hat{\beta}}(\beta, \theta)$, to obtain

a θ that maximizes the value of $l_{\beta=\hat{\beta}}(\beta, \theta)$, where

$$l_{\beta=\hat{\beta}}(\beta, \theta) = -\frac{1}{2} \left(\sum_i n_i \times \ln(2\pi) + \sum_i \ln(\det(\mathbf{V}_i)) + \sum_i (\mathbf{y}_i - \mathbf{X}_i\hat{\beta})^T \mathbf{V}_i^{-1} (\mathbf{y}_i - \mathbf{X}_i\hat{\beta}) \right) \quad (5)$$

where $\mathbf{V}_1, \dots, \mathbf{V}_M$ are functions of θ . Typically, $l_{\beta=\hat{\beta}}(\beta, \theta)$ is not a linear function for θ .

Consequently, no analytical solution for θ exists, and an algorithm must therefore be used to obtain a numerical solution for θ . Commonly used algorithms include the expectation-maximization (EM) algorithm, Newton's method, and Fisher's scoring algorithm. Previous studies have described these algorithms in detail [36, 37, 38], including a comparison of their strengths and weaknesses [35]. An algorithm can be used to obtain a numerical solution for θ (i.e., $\hat{\theta}$), the result of which can be

converted to $\hat{\mathbf{V}}_i$. Subsequently, the calculation is performed iteratively by using Equations (4) and (5) until the values of $\hat{\beta}$ and $\hat{\theta}$ converge.

REML estimation method The REML method is another approach for estimating θ . The REML estimate of θ is obtained by applying an iterative method to a restricted natural-logarithm ML function.

$$l_{REML}(\theta) = -\frac{1}{2} \left((\sum_i n_i - p) \times \ln(2\pi) + \sum_i \ln(\det(\mathbf{V}_i)) + \sum_i (\mathbf{y}_i - \mathbf{X}_i\hat{\beta})^T \mathbf{V}_i^{-1} (\mathbf{y}_i - \mathbf{X}_i\hat{\beta}) + \sum_i \ln(\det(\mathbf{X}_i^T \mathbf{V}_i^{-1} \mathbf{X}_i)) \right) \quad (6)$$

Regarding the difference between the restricted natural-logarithm ML function (6) and Equation (5), Equation (6) accounts for the loss in degrees of freedom. Therefore, the estimator of θ obtained using the REML is an unbiased estimator. The REML method involves applying Equation (4) to obtain the estimator of β . For the REML, Equations (4) and (6)

are iteratively used until the values of $\hat{\beta}$ and $\hat{\theta}$ converge. Equation (4) is used in both the ML and REML estimation methods to estimate β . However, the functions employed to estimate θ (i.e., the ML and REML methods use Functions (4) and (6) to estimate θ , respectively) differ between these methods, and they thus yield different values for $\hat{\theta}$. In addition,

because $\hat{\mathbf{V}}_i$ is a function of $\hat{\boldsymbol{\theta}}$, different values are obtained for $\hat{\mathbf{V}}_i$; consequently, different $\hat{\boldsymbol{\beta}}$ values are obtained through using these two methods.

Estimating random effect parameters Given \mathbf{b}_i , the following equation can be derived from (1):

$$\mathbf{y}_i | \mathbf{b}_i \stackrel{d}{=} \mathcal{N}(\mathbf{X}_i \boldsymbol{\beta} + \mathbf{Z}_i \mathbf{b}_i, \boldsymbol{\Lambda}_i)$$

where " $\stackrel{d}{=}$ " represents "distribution equals" and $\boldsymbol{\Lambda}_i$ is given by (2). Therefore, the generalized least squares method can be applied to estimate \mathbf{b}_i , which is equal to $(\sum_i \mathbf{Z}_i^T \boldsymbol{\Lambda}_i^{-1} \mathbf{Z}_i)^{-1} \sum_i \mathbf{Z}_i^T \boldsymbol{\Lambda}_i^{-1} (\mathbf{y}_i - \mathbf{X}_i \boldsymbol{\beta})$. In the equation, $\boldsymbol{\Lambda}_i$ (a function of $\boldsymbol{\theta}$) and $\boldsymbol{\beta}$ are true values. Therefore, by substituting the ML or REML estimates (i.e., $\hat{\boldsymbol{\beta}}$ or $\hat{\boldsymbol{\Lambda}}_i$), we can obtain the estimator of \mathbf{b}_i as follows:

$$\hat{\mathbf{b}}_i = (\sum_i \mathbf{Z}_i^T \hat{\boldsymbol{\Lambda}}_i^{-1} \mathbf{Z}_i)^{-1} \sum_i \mathbf{Z}_i^T \hat{\boldsymbol{\Lambda}}_i^{-1} (\mathbf{y}_i - \mathbf{X}_i \hat{\boldsymbol{\beta}}).$$

C. Forecasting Research Variables

After the explanatory variables \mathbf{X}_i^{new} and \mathbf{Z}_i^{new} have been obtained, the estimates of $\boldsymbol{\beta}$ and \mathbf{b}_i (i.e., $\hat{\boldsymbol{\beta}}$ and $\hat{\mathbf{b}}_i$) described in the previous section can be used to forecast the research variable \mathbf{y}_i . The predictive value is as follows:

$$\hat{\mathbf{y}}_i = \mathbf{X}_i^{pred} \hat{\boldsymbol{\beta}} + \mathbf{Z}_i^{pred} \hat{\mathbf{b}}_i. \quad (7)$$

IV. A CASE STUDY

This study adopted a single-level linear mixed-effect model to forecast product demand. In the case study, the sample was a leading professional industrial LCD/OLED display manufacturer. This manufacturer produces products that are critical components of various devices used in daily life and are applied in various industries. Moreover, the company has an international customer base. Table 2 shows the number of orders, total product demand, average product demand per order, and quantity of finished goods from 2009 to 2013. Before 2013, the manufacturer produced more than 5,000 product types, and the average quantity of products required in an order was approximately 400. Thus, the manufacturer is considered to be a suitable example of a business that produces a diverse combination of high-mix products.

A characteristic of high-mix low-volume manufacturers is that they typically commence production only after receiving a customer order. This production pattern is typical of the MTO production pattern, which is mainly adopted to serve customers in

niche markets. In recent years, the manufacturer's profits have decreased despite an increasing revenue and market share. Therefore, the manufacturer aimed at changing its production strategy by adopting the MTS production strategy for some product types in order to increase its batch production capacity, reduce its production costs, and improve its production efficiency. In addition, the manufacturer believed that adopting the MTS production strategy would enhance

Table 2. NUMBER OF ORDERS AND PRODUCT DEMAND

Year	Number of orders	Total product demand	Average product demand for an order	Finished goods quantity
2009	12,929	3,603,141	278.69	2,727
2010	17,968	8,343,884	464.37	3,518
2011	20,169	6,721,194	333.24	4,546
2012	22,589	8,062,890	356.94	5,822
2013	22,361	9,045,056	404.50	5,468

customer satisfaction by ensuring the rapid delivery of customer orders, thereby providing a competitive advantage. Thus, being able to accurately forecast product demand was crucial. Following evaluation, to test the implementation of the MTS production strategy, this study selected the top 20 standard finished products that were most frequently ordered between 2011 and 2013 by customers of the sample manufacturer. As shown in Figure 1, these 20 standard products accounted for 20% of the manufacturer turnover for standard products in 2013, with 86 orders placed in the same year. After implementing the MTS production strategy, the manufacturer planned to run production of each product type once per month per year. Accordingly, the production frequency, cost of handling orders, and frequency of changing production lines was reduced. Thus, its long-term production capacity plans can be implemented to maximize the benefits of producing a high volume of products with fewer runs.

A. Data Structure

The data structure comprised 20 types of standard finished products. The monthly product demand data were collected from January 2007 to December 2013 for each product type (see S1 Table). The historical data before 2012 were used to estimate model parameters, and the model was used to forecast the product demand for 2013 (January–December). Not all 20 products were manufactured from 2007. The historical data used to estimate model parameters comprised 1295 observation values (64 observation values on average for each product type). The product lifecycle varied by year, and the product demand varied by month. Therefore, year and month were crucial predictors. For each type of product, the monthly product demands in each month were related. In this study, the explanatory variables (year and month) were added to the linear mixed-effect model

to analyze the monthly product demand data. Regarding product sales, the product demand varied by product type. Accordingly, product type was regarded as a crucial categorical variable because of its influence in forecasting the product demand. In this study, according to the characteristics of the mixed-effect model, we used product type as a random-effect term and included the demand for each product type in a universal model to

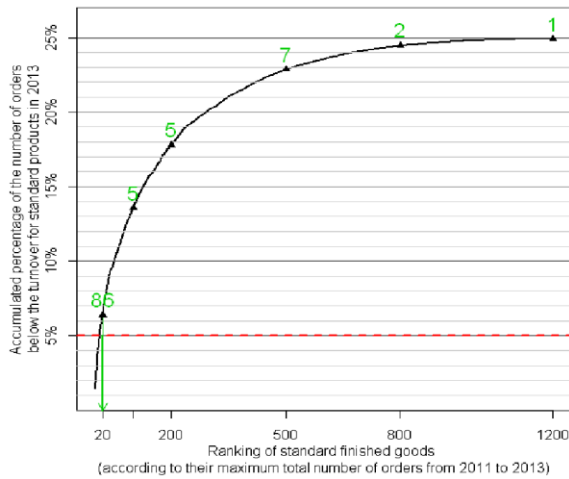


Figure 1. Maximum total number of orders (2011–2013). The plot shows that the accumulated percentage of the maximum total number of orders from 2011 to 2013 is less than the turnover for standard products in 2013. The first 20 products accounted for approximately 20% of the turnover for standard products. The numbers in green denote the number of orders for standard products in 2013 corresponding to the horizontal axis. forecast the demand for type separately. Subsequently, we compared other commonly used forecasting methods. Unlike the mixed-effect model, other methods did not have a universal model to account for 20 unique product types. Therefore, for the other forecasting methods, the data are required to be divided into multiple data sets according to product type, and the partitioned data are then applied to the forecasting methods depending on the product type for analysis and forecasting. This approach substantially reduces the sample size, reducing the accuracy of the forecast.

B. Model Development

Product demand differed by product type, and thus we assumed the demand for each type of product to be mutually independent. In Model (1), which is the single-level model, random effect was set to be product type, thus yielding various random-effect coefficient for each product type. The model is expressed as follows:

$$\begin{aligned}
 \mathbf{y}_i = & \beta_0 + \beta_1 \times (\text{year}-2007) \\
 & + \beta_2 \times (\text{year}-2007)^2 + \text{month} \times \beta_3 \\
 & + b_{i0} + b_{i1} \times (\text{year}-2007)^2 + \varepsilon_i
 \end{aligned} \quad (8)$$

where \mathbf{y}_i is a vector that denotes the monthly product demand (the vector length is equal to the data quantity for product i); β_0 , β_1 , β_2 , and β_3 denote the intercept, year, year-squared, and month for the fixed-effect term; and b_{i0} and b_{i1} denote the intercept and year-squared for the random-effect term. In Model (8), year was considered as a continuous variable with 2007 used as the baseline. Month was a categorical variable; therefore, the month term in Model (8) was a dummy variable. The dummy variable for month had 11 indicator variables with a value of 0 or 1, and the total product demand in January was used as the baseline. Expressing Equation (1) as Model (8), the fixed-effect explanatory variable \mathbf{X}_i is a matrix comprising a column of 1's vector for the intercept, year, year-squared, and month covariates. Thus, the expression $\beta = [\beta_0 \ \beta_1 \ \beta_2 \ \beta_3]^T$ is a 14×1 vector, where β_3 is the coefficient of the dummy variable for the month covariate and has 11 elements. To account for the various product types, we chose the intercept and year-squared covariate as the random-effect explanatory variable, where the intercept was used to account for the average difference of demands between product types, and the year-squared covariate was used to consider the difference between product demands decreased or increased over time. The explanatory variable \mathbf{Z}_i in the random-effect explanatory variable comprised the intercept and year-squared covariate, of which the coefficients are a 2×1 vector expressed as $\mathbf{b}_i = [b_{i0} \ b_{i1}]^T$. In Model (8), the year-squared covariate in the random-effect explanatory variable was also a part of the fixed-effect explanatory variable, and was used to account for the fact that the expectation of \mathbf{b}_i was probably unequal to 0; thus, the assumption that \mathbf{b}_i in (2) was equal to 0 was reasonable. The year-squared covariate was included to prevent the annual growth trend from being linear, which enabled the model to more accurately reflect the current situation. The year-squared covariate is crucial to practical operations. The year and year-squared covariates added into the fixed-effect explanatory variable facilitated establishing a grand model for the 20 product types. The year and year-squared covariates for the fixed effect indicated the average growth trend for the 20 product types, whereas the random effect reflected the specific annual growth trends for each product type. To forecast the monthly product demand for 2013, 2013 was used as the value for the year and year-squared covariates. Both covariates and the target month were input into the explanatory variable to form \mathbf{X}_i^{new} and \mathbf{Z}_i^{new} . Subsequently, $\hat{\beta}$ and $\hat{\mathbf{b}}_i$ in (7) were used to obtain the forecasted value $\hat{\mathbf{y}}_i$.

C. Other Forecasting Methods

Comparing forecasting methods is crucial in methodological studies [39, 40, 41, 42, 43]. The

model proposed in this study was compared with commonly used statistical forecasting methods, beginning with the following linear model:

$$Y_j = \alpha_0 + \alpha_1 \times (\text{year}_j - 2007) + \alpha_2 \times (\text{year}_j - 2007)^2 + \alpha_3 \times \text{month}_j + \delta_j \quad (9)$$

Table 3. Linear Mixed-Effect Model Versus the Linear Model.

Explanatory variable	Linear mixed-effect model			Linear model		
	Coefficient	Standard error	P value	Coefficient	Standard error	P value
The intercept term	39.46	320.14	.9019	174.54	294.07	.5529
(Year-2007)	800.55	133.52	.0000 ***	746.35	153.69	.0000 ***
(Year-2007) ²	-99.97	25.82	.0001 ***	-93.23	27.62	.0008 ***
February	206.41	283.03	.4660	171.14	327.19	.6010
March	736.88	281.57	.0090 **	716.23	325.51	.0280 *
April	753.30	281.56	.0076 **	762.56	325.50	.0193 *
May	536.51	280.89	.0564 -	504.53	324.70	.1205
June	253.56	281.62	.3681	218.06	325.53	.5031
July	591.73	271.46	.0295 *	556.53	313.77	.0764 -
August	91.35	271.48	.7366	56.21	313.77	.8579
September	711.75	271.46	.0088 **	664.40	313.77	.0344 *
October	297.69	271.05	.2723	255.00	313.28	.4158
November	473.91	272.52	.0823 -	432.47	314.94	.1699
December	360.30	270.62	.1833	308.34	312.71	.3243

“- ”: p < .1; “* ”: p < .05; “** ”: p < .01; “*** ”: p < .001.

where α_0 , α_1 , α_2 , and α_3 are regression coefficients and α_3 denotes the coefficient of the dummy variable for the month covariate, and δ_j is the error term. Model (9) (i.e., the linear model) includes only the fixed-effect term in Model (8) (i.e., the mixed-effect model); therefore, Model (9) was compared with Model (8) to examine the differences when the random-effect term is present or absent in the model. A total of 1295 observations of monthly product demand (Y_j , $j = 1, \dots, 1295$) were used to estimate the coefficients in Model (9) and the significance of the coefficients with P values. In the Results section, Models (8) and (9) are compared regarding forecast accuracy and the P values.

Next, the model proposed in this study was compared with the exponential smoothing method, in which the product demand observation values Y_t 's and its predictive values F_t 's were used to obtain the predictive values for the subsequent period by calculating a weighted mean. The forecast formula is as follows:

$$F_{t+1} = \alpha Y_t + (1 - \alpha) F_t$$

where α is the weighted coefficient. To accurately forecast the monthly product demand in this case, we adjusted the exponential smoothing method to account for two influential factors (i.e., month and product type). The data were divided into 20 data sets according to each product type, and each data set was divided into 12 subsets (one for each month). For each product type, no more than six observations from each month in the historical data were used. The pre-2012

monthly product demand data were used to forecast the product demand for the corresponding months in 2013. The weighed coefficient was $\alpha = \frac{1}{2(N+1)}$,

where N is the number of observations for a month ($N \leq 6$).

Finally, the model proposed in this study was compared with a seasonal time-series model; specifically, the autoregressive moving average model

(ARMA(2,2)₁₂), which was considered to be a suitable model because the data were not nonstationary time-series data. The mathematical model for ARMA (p, q)_s is expressed as follows:

$$(1 - \sum_{i=1}^p \phi_i B^{s \times i}) Y_t = (1 + \sum_{i=1}^q \theta_i B^{s \times i}) \xi_t$$

where ϕ_i is the i th order autoregressive process coefficient, B is a backward shift operator, θ_i is the i th order moving-average process coefficient, ξ_t is a normally distributed confounding term, and s is a seasonal parameter. Longitudinal data were collected for each of the 20 product types. A time-series model was established for each of the 20 product types. In this case, the month was regarded as a crucial influential factor for forecasting and thus the seasonal parameter s was set to 12, which indicates the existence of correlations in the data for every 12 month. The samples were categorized by product type, yielding an average of 64 samples for each type of product. The parameters p and q were determined based on the characteristics of an autocorrelation function, a partial autocorrelation function, and an extended autocorrelation function (p = 2 and q = 2). Finally, the ARMA(2,2)₁₂ model was used to forecast the product demand for each product type.

Table 4. Error Indicators for the Four Forecasting Methods.

	MAE		MAPE		RMSE	
	M	SD	M	SD	M	SD
Linear mixed-effect model	1,412.71	1,500.04	1.52%	1.50%	1,849.42	1,919.86
Linear model	1,828.96	2,091.93	3.77%	6.00%	2,259.99	2,712.69
ARMA(2,2) ₁₂	1,509.22	1,938.23	1.92%	2.04%	1,942.48	2,533.25
Exponential smoothing method	1,565.54	1,547.88	2.01%	1.77%	2,003.87	2,193.16

D. Results

In this study, mean of absolute error (MAE), mean of absolute percent error (MAPE), and root-mean-square error (RMSE) were used as error indicators. The definitions for these error indicators are provided as follows:

$$MAE = n^{-1} \sum_{t=1}^n |F_t - Y_t|$$

$$MAPE = 100n^{-1} \sum_{t=1}^n \left| \frac{F_t - Y_t}{Y_t} \right|$$

$$RMSE = \left(n^{-1} \sum_{t=1}^n (F_t - Y_t)^2 \right)^{0.5}$$

where n denotes the number of months to be forecasted (n = 12 in this case), Y_t represents the true product demand for month t of 2013, and F_t is the forecasted product demand for month t. The fixed-effect term in the linear model was compared with that in the linear mixed-effect model. As shown in Table 3, the absolute values of the coefficients for the explanatory variables in the linear mixed-effect model containing the random-effect term are greater (i.e., further from 0) than all of those in the linear model except for April. In addition, the standard errors and P values for all of the explanatory variables in the linear mixed-effect model are smaller than those in the linear model. Regarding the linear fixed-effect model, compared with January in a given year, the product demand was significantly greater in May and November (P value < 0.1), in July (P value < 0.05), and in March, April, and September (P value < 0.01). Compared with the linear fixed-effect model, the linear model yielded less significant results. The linear model is suitable for data containing mutually independent observation values. In this case, the observation values for product demand were correlated over time, thereby violating the assumption of the linear model. Therefore, the standard errors and P values for the linear model (Table 3) are not valid estimates, whereas those for the linear mixed-effect model are more reliable. Table 4 shows the error indicators for the four forecasting methods. Because this case involved three error indicators for each of the 20 product types, Table 4 presents the mean and standard deviation of the three error indicators. As shown in Table 4, the means and standard deviations of MAE, MAPE, and RMSE for the linear mixed-effect model are lower than those for the linear, ARMA, and exponential smoothing models, indicating that, in this case, the linear mixed-effect model is superior to the other three models. Regarding the model comparison (Table 5), the predictive values obtained through using the linear model to process the correlated data are unbiased [23]. However, the linear mixed-effect model (8) contains the random-effect term, whereas the linear model (9) does not. Therefore, in Model (8), the intercept and year-squared terms differ according to the product type, and thus the corresponding intercept values and coefficients differ based on the product type. In Model (9), the covariate of product type is not included in the explanatory variables, which generates identical predictive values for various product types in the same years and months. Thus, this model cannot predict the product demand for the individual product types, rendering its forecasting effectiveness inferior to that of Model (8). Regarding the exponential smoothing method, we considered product type and month as crucial influential factors, which were used

as the basis for dividing the data into 240 data sets. For each product type, the pre-2012 monthly data were used to forecast the monthly product demand for 2013. In this manner, the exponential smoothing method was applied 12 times for each of the 20 product types. In addition, less than six observations from the historical data were used in the exponential smoothing method (for a given month, there were at most 6 sets of data from 2007 to 2012); consequently, the risk of inferential error was high because only a few observations were involved in the prediction. Regarding the seasonal time-series model ARMA(2,2)₁₂, we considered product type as a crucial influential factor and divided the data into 20 data sets according to product type. For each product type, 64 observations were used on average. The ARMA(2,2)₁₂ model was used to forecast the product demand for each product type by considering the correlation between the data for every 12 month. For both the exponential smoothing method and the ARMA(2,2)₁₂ model, the data were divided into subsets according to the product type and then used to estimate the monthly effect of each product type. Accordingly, although such procedure could consider the various monthly effects for various product types and the interaction between product type and month, it reduces the number of data observations involved in the prediction. In the linear mixed-effect model, 1295 data observations were used to estimate the random effect for each product type. The number of data observations used in the linear mixed-effect model was considerably more than that used in the exponential smoothing and time-series models, which could explain

Table 5. Comparison of the Four Models.

	Number of models	Number of samples	Consideration for the effect of product type	Consideration for the effect of month	Consideration for the interaction effect of product type and month
Linear mixed-effect model	1	1,295	○	○	※1
Linear model	1	1,295		○	
ARIMA(2,2)	20	≤72	○	○	○
Exponential smoothing method	240	≤6	○	○	○

※1 This effect is nonsignificant

why the linear mixed-effect model produced lower forecast errors. In addition, in Model (8), the random effect of the interaction term for month and year-squared term was considered and the likelihood ratio test was employed to examine whether this term is significant to this model. The results showed that only the random effects of the intercept and year-squared terms were significant, and the random effect of the month term did not significantly enhances its explanatory power for the data. Therefore, the random

effect of the interaction term was not included in Model (8).

V. DISCUSSION

In summary, when applying the linear mixed-effect model, all of the historical data were used in one model to predict the monthly product demand for each product type, and to avoid problems resulting from dividing the data into smaller data sets. In this case study, using the linear mixed-effect model enables manufacturers who adopt the MTS production strategy to predict the amount of inventory they should stock. Furthermore, the model is more effective in forecasting product demand than is the time-series, exponential smoothing, and linear models.

Similar to the linear model, the linear mixed-effect model is typically used to examine the relationship between explanatory and research variables. Unlike the linear model, which assumes the observation values to be mutually independent, the linear mixed-effect model is suitable for examining correlated data. Because the data pertaining to business operations are generally correlated over time, the linear model is limited in applicability. By contrast, the linear mixed-effect model was initially developed to handle correlated data. Other methods such as the time-series and exponential smoothing methods formulate the correlation between observation values as parameters, and then estimate the parameters by data and forecast the observations by the estimates. When the time-series and exponential smoothing models were first developed, these methods were not aimed at analyzing the relationship between explanatory and dependent variables. Wang [19] proposed an exponential smoothing method that included explanatory variables and can be used to explore the association of research variable. Because this method is a relatively new development, most of statistical software packages have not yet incorporated related functions, and thus this method has not been widely used. By contrast, the linear mixed-effect model was developed more than 30 years ago, and related functions have been included in various statistical software packages.

Using linear mixed-effect, time-series, and linear models to forecast product demand can yield negative predictive values. This phenomenon occurs when the linear mixed-effect model is used because ε_i in (2) is assumed to be normally distributed and the link function is an identity function. Negative values are usually obtained from historical data where product demand is zero or very low. To prevent this, predictive value was truncated at 0 (i.e.,

$F_t = \max(\hat{Y}_t, 0)$, where \hat{Y}_t denotes a predictive value derived from any method, and F_t denotes an actual predictive value obtained from any prediction

method). In other words, if $\hat{Y}_t > 0$, then $F_t = \hat{Y}_t$; if $\hat{Y}_t \leq 0$, then $F_t = 0$. Some link functions in generalized linear mixed-effect model can deal with the case where dependent variable is restricted to $\hat{Y}_t \geq 0$ [44]. However, the prediction intervals for the random-effects in linear mixed-effect model are well developed [45, 46, 47, 48, 49]. It is useful to apply the prediction intervals in business operations for knowing whether the random-effect exists.

Implementing an MTS production strategy can enhance the competitive advantages of a manufacturer, enabling the manufacturer to rapidly satisfy product demand, thereby reducing internal and external transaction costs for handling orders. Employing this strategy also enables high batch centralized production and thus can reduce production costs and assist manufacturers in negotiating with material suppliers about the cost of materials. Because this approach enables short delivery times, customer satisfaction can be improved, thus attracting potential customers who need products immediately. Consequently, market share can be increased. MTS production also enhances the usage rate of production equipment. Companies that adopt an MTS strategy require an accurate forecasting method to realize these advantages. This study proposed an accurate forecasting method for determining the stock levels a company should determine for adopting the MTS production strategy, a topic that has seldom been discussed in studies on MTS production.

Using an MTS production strategy involves the potential risk of increasing inventory costs. Therefore, future studies should adequately apply the strengths of the linear mixed-effect model (e.g., accurately forecasting demand for multiple product types in one go) when forecasting. Future studies should consider investigating whether the forecasting intervals of the linear mixed-effect model can be coupled with various inventory strategies to assist manufacturers with adopting the MTS production strategy in order to develop an optimal business operation model in terms of optimal inventory time points and minimal inventory costs. In addition, to remain competitive, companies should enhance their organizational capability for elevating the threshold that enables competitors to develop similar operating models. Future studies are also recommended to explore the benefits that the MTS production strategy involving a linear mixed-effect model brings to the various departments of an enterprise and the effects of such strategy on customer satisfaction and loyalty.

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