ROLE OF SOCIAL CAPITAL IN EMPLOYEE PRODUCTIVITY IN IRANIAN BANKS

[1]MORTEZA RAEI DEHAGHI, [2]MOJTABA MOLAAHMADI

[1,2]Department of Management, Dehagh Branch, Islamic Azad University, Dehagh, Isfahan, Iran.
E-mail: [1]dr_mraeidehaghi@yahoo.com.ph, [2]manager@iaudehagh.ac.ir

Abstract- The purpose of this study is to investigate the role of social capital in employee productivity in the selected banks in Isfahan Province. It is a descriptive-correlational approach, and the statistical population includes 115 bank employees in 2014-2015 that are selected through simple random sampling. Tools of data collection were Nahapiet and Ghoshal's social capital questionnaire and Hersey and Goldsmith's productivity questionnaire. The collected data was analyzed at descriptive and inferential statistics levels including independent t-test, variance analysis, Pearson correlation coefficient, and regression analysis. The results disclosed that cognitive dimension of social capital has a slight predictability (β=0.013) for productivity but in turn, the structural and relational dimensions of social capital have the highest predictability for productivity with predictable values equal to β= 0.625 and β= 0.267.

Keywords- Social Capital, Productivity, Selected Banks in Isfahan Province.

I. INTRODUCTION

Social capital is a modern concept that nowadays has been proposed in economic and social investigations of modern communities and has been led to theories that are the basis for other management studies. This capital plays a more important role than physical and human capital in corporations and communities. It is the result of group and social interactions and norms and unlike other capitals, it does not exist physically. Increasing of this capital can reduce administration expenses of society seriously as well as operating costs of firms. Also, an acceptable amount of social capital facilitates social interactions so that it can be used as the most principal source to solve the problems and modify the current processes under critical conditions. Social capital is regarded as the infrastructure of economic development in any community. Importance of this capital in economic development is to the extent that it can be observed in economic prosperity of all developed communities clearly. Social capital shapes people's behavior aside for the formation of moral and behavioral rules and regulations and helps the growth and dynamism of human capital and physical and economic capital in interaction with each other [1].

In the current high competitive world, productivity as a philosophy and viewpoint based on improvement strategy constitutes the most important objective of any firm [2]. On the other side, one of the effects of social capital is to increase labor force productivity. To put it differently, it can be stated that the driving force for any kind of productivity is the manpower. Banks are the major element of the financial system in every economy and play a determinant role. Also, they are the most important tool of growth and development of countries. Positive and effective activities of banks can have significant effects on the growth of economic sectors and enhancement of productions in each sector or prosperity in some economic aspects [3].

Given the importance of the above issues and their effect on each other, the present study investigates the role of social capital in employee productivity in the selected banks in Isfahan Province.

II. STATEMENT OF THE PROBLEM

Today, it is highly necessary for firms to distinguish themselves through their intangible assets by moving toward the global economy and ever-increasing competitiveness. Social capital is one of these intangible assets. This capital is created among the members of a social system (for instance a firm) through social relations and interactions [4].

One of the major issues of social capital that managers are facing with is to improve employees' performance and thus increase productivity of a firm. In addition, labor force is the important and effective factor in productivity. Employees are valuable assets of any firm. Achieving the purposes of each firm depends on proper management of these valuable resources.

Hence, social capital can have economic, social and political advantages and banks can achieve more favorable and lower cost results due to the existence of social capital. Similarly, firms (for instance banks) can understand inter-personal and group interactions better by recognition and identification of social capital dimensions and can direct their organizational system better. Components such as trust, voluntary participation, and the like in social capital cause to decrease management expenses such as formal supervision and control, managerial consultations, the slowness due to bureaucratic system, etc. and the possibility to use the time and capital to perform higher productivity activities is provided [5]. Bank managers should pay attention to the importance of social capital as a vital element to improve the

function of the system under their supervision, increase customer satisfaction and finally achieve and maintain competitive edge because of economic activities in their firm.

III. SIGNIFICANCE OF THE STUDY

Existence of social capital is the key to establish civil society and finally obtain sustainable development. In the absence of social capital, other capitals lose their effectiveness and as a result, fulfillment of development paths and cultural and economic evolution will become difficult [6].

On the other hand, productivity is an important concern for firms. It is a combination of efficiency and effectiveness that emphasizes qualitative and quantitative issues simultaneously. Happiness and prosperity of each nation depends on work and attempt of all people and productivity is a criterion for performance assessment of these activities and attempts in various socio-economic sectors. Since productivity especially labor force productivity is the major origin of economic growth and national welfare, the human factor must be considered at different country levels [7].

Generally speaking, conducting the current study has become necessary since bank managers pay less attention to the issue of social capital in banks and perhaps some of them are not familiar with this topic. Moreover, the business world in the competitive era and competition among the banks and paying attention to degree of productivity and efficiency in a system, its measurement and simultaneous evaluation of feedbacks have attracted the attention of managers to the effective factors on increased productivity in a firm. On the other hand, given the previous studies it is obvious that social capital has not been ineffective on productivity and efficiency.

IV. LITERATURE REVIEW

Social capital is a concept that nowadays has been proposed in economic and social studies of developed societies. It is social communications and networks that can create cooperation and confidence among the people. Unlike other capitals, social capital does not exist physically; rather it is the result of group and social norms and interactions wherein, its increase can reduce administration expenses of society as well as operating costs of the firms seriously [8].

The issue of productivity and the necessity to improve, enhance and pay attention to it have been regarded as one of the unavoidable necessities in firms. Productivity is a perfect and general concept that its increase as necessity to enhance living standard, more welfare, and convenience of people, has always been considered by those who are in charge of politics and economics and the statesment and is a major purpose for all countries. The important role of productivity enhancement in achieving managers' purposes cannot be ignored. Productivity is an important tool by which people can evaluate their firm and determine to what extent the existing resources have been employed favorably [9].

Bank is one of the institutions that has a significant role in economy of each country. Banks do their tasks by attracting deposits of people and working with the collected funds and if they can use the current resources toward their activities efficiently, they are able to achieve their purpose. Given the competitive world of banks with each other and paying attention to degree of productivity and efficiency in the system, managers have paid special attention to the issue that which factors can be effective on increased productivity in their firm. On the other side, considering previous studies about social capital and its effect on topics such as productivity and efficiency, job satisfaction, entrepreneurship, etc. it is obvious that social capital has been effective on each one of the above factors. Hence, paying attention to social capital and attaching importance to it can be useful for managers to improve and develop their firm.

In previous decades, several studies have been conducted about social capital and productivity and their consequences. Among these studies, the cases below can at least be mentioned.

Ahmadi and Mohamadi Bolbolan Abad [10] investigated the relationship among social capital dimensions and organizational citizenship behavior among the employees of customs duties in Kordistan province. They concluded that employees' social capital index in cognitive dimension has had the highest effectiveness on organizational citizenship behavior of the employees under study.

Khezrpour et al. [11] explored the relationship between social capital and productivity in employees of departments of sports and youth affairs in West Azerbaijan province and concluded that there is a direct and significant relationship among social capital and entrepreneurship, sport participation, productivity, labor productivity, employee commitment, and economic growth. Similarly, paying attention to social capital is unavoidable in order to enhance employees' productivity.

In a survey entitled "exploring the effective variables on productivity of the faculty members in Payame Noor University of Hamedan province" by emphasizing the role of social capital in 2014, Bakhtiari [12] concluded that there is a significant relationship between social capital dimensions (organizational support, feedback, credit, motivation, ability, understanding and cognition, consistency) and productivity. Moreover, it was showed that the most important effective dimension of social capital on productivity is work ability.

Vafaei Najar et al. [13] explored the relationship between social capital and performance of nurses in hospitals in Mashhad (among 320 nurses in the hospitals related to Mashhad University of Medical

Sciences) and reached to the conclusion that social capital of nurses has a direct relationship with their performance. Therefore, reinforcement of the factors related to social capital (including understanding, cognition, and trust) can improve performance of these employees.

In a survey entitled "the relationship between intellectual capital, social capital and labor force productivity in employees of branches of Bank Sepah in Golestan province" that was conducted on 185 employees, Pourghorban et al. [14] concluded that there is a significant relationship and a high positive correlation among social capital dimensions, intellectual capital dimensions and labor force productivity. Likewise, social capital can be considered as one of the organizational assets.

The results of studies by Sabatini [15] and Greve et al. [16] that was conducted in Italy, revealed that the employees in this country showed that there is a positive and significant relationship between social capital and productivity. In other words, whatever employees' social capital is enhanced, their productivity is increased too. The reason is that social capital referring to relations among the members of a network as a valuable resource leading to the realization of purposes of members and increased productivity by creating norms and mutual trust.

Salaran [17] conducted a survey entitled "social capital and productivity in higher education institutions in Australia". It was carried out in public universities in Melbourne that aimed to explore the role of social capital in increasing of productivity in academic institutions. He concluded that there is a strong and significant correlation among social interactions and productivity. Hence, the relationship between faculty members and their colleagues and other employees must be facilitated in universities.

In a study entitled "social capital in project-based firms" Vincenzo and Mascia [18] investigated the role of social capital in project performance in 54 organizational projects. They found that the project performance level is related considerably to social capital structure. Chuang et al. [19] carried out a study entitled "human resources management techniques and corporate social capital" on 161 companies in China and concluded that human resources management techniques are effective on social capital. Similarly, facilitation of relations among the employees has a positive effect on social capital. In their survey entitled "human capital, social capital and labor force productivity", Delmas and Pekovic [20] found that labor force productivity is increased if human capital and social capital are enhanced. In a study entitled "the effects of social capital on school performance" that was conducted in elementary schools in Mississippi, America, Misra et al. [21] concluded that the elementary schools located in places with higher social capitals have better performance than those located in places with relatively low social capitals.

Given the above theoretical principles, it is totally obvious that optimal use of financial, physical, and human capitals in the firm without social capital, i.e. without the network of mutual relations among the members along with trust, kindness, friendship, and maintaining organizational values and norms is not possible. This capital realizes the objectives by creating norms and mutual trust with cognitive and structural dimensions. It is possible to save costs by productivity that is the combination of efficiency and effectiveness. Improvement of productivity in a firm is the result of optimal, effective and efficient use of resources, reduction of wastes, decreased fixed price, improved quality, enhanced customer satisfaction as well as motivation and interest of employees that are at least led to the growth and development of a firm.

Previous studies conducted in exploring the effective factors on productivity have shown that social capital is effective on productivity and increasing of labor force productivity is one of the effects of social capital.

V. METHODOLOGY

This study is descriptive-correlational given the main purpose of the study that is exploring the role of social capital in employee productivity (in the selected banks in Isfahan province).

5.1. Statistical population

The statistical population included all employees of the selected banks in Isfahan province in 2014-2015 that were equal to 174.

5.2. Sample, sample size, and sampling method

Given Morgan's sample size, 115 employees were selected as the research sample. They were selected from the list of employees' name through simple random sampling method.

5.3. Data collection method, Tools and Analysis

Documentary study and field study were employed for data collection. Questionnaire was tool of data collection. Nahapiet and Ghoshal's [22] questionnaire was used to measure social capital and Hersey and Goldsmith's [23] questionnaire was employed to measure productivity. Descriptive and inferential statistics methods were obtained with the use of SPSS-18 software for data analysis.

VI. RESULTS

In this section, the research data including the main hypotheses along with subsections of secondary hypotheses is analyzed through inferential statistics tests. The results of testing the hypotheses are shown in Tables 1, 2, and 3.

Main hypothesis 1: Structural dimension of social capital plays a role in employee productivity in the selected banks in Isfahan Province.

Table 1: Results of linear regression about the effect of structural dimension of social capital on employee productivity

Statistical Index / Predictor variable		Structural dimension
Criterion variable		Productivity
Nonstandard beta coefficients	beta	0.267
	Standard error	0.059
Standard beta coefficients		0.392
T statistic		4.53
Significance level		<0.001

Main hypothesis 2: Cognitive dimension of social capital plays a role in employee productivity in the selected banks in Isfahan Province.

Table 2: Results of linear regression about the effect of cognitive dimension of social capital on employee productivity

Statistical Index / Predictor variable		Cognitive dimension
Criterion variable		Productivity
Nonstandard beta coefficients	beta	0.013
	Standard error	0.022
Standard beta coefficients		0.058
T statistic		0.620
Significance level		0.536

Main hypothesis 3: Relational dimension of social capital plays a role in employee productivity in the selected banks in Isfahan Province.

Table 3: Results of linear regression about the effect of relational dimension of social capital on employee productivity

Statistical Index / Predictor variable		Relational dimension
Criterion variable		Productivity
Nonstandard beta coefficients	beta	0.625
	Standard error	0.087
Standard beta coefficients		0.559
T statistic		7.170
Significance level		0.001>

According to results presented in tables 1,2 and 3, relational dimension of social capital has had the highest effect (β=0.625) on employee productivity. In the second order, there is structural dimension with impact factor equal to β=0.267. This effect is considerable and significant statistically (P value<0.05) but cognitive dimension with slight impact factor (β=0.013) has not had a considerable effect on employee productivity (P value>0.05).

DISCUSSION AND CONCLUSION

The present study aimed to explore the role of social capital in employee productivity in the selected banks in Isfahan Province. To this end, 115 employees were selected and social capital questionnaire and productivity questionnaire were employed for data collection. Values of Cronbach's alpha coefficient for both questionnaires were more than 0.7 that showed suitable coherence of the questions. The collected data via questionnaires was analyzed through independent t-test, variance analysis, Pearson correlation coefficient, and regression analysis.

The results disclosed that cognitive and relational dimensions of social capital in banks are at a desirable upper limit in viewpoint of employees, but in contrast, the structural dimension has the lowest value and this shows that the status of structural dimension of social capital is at a desirable limit. Similarly, exploring total status of social capital showed that this mean has a significant difference from the desirable limit statistically. Therefore, it can be stated that social capital has been desirable and partially excellent in viewpoint of employees.

ACKNOWLEDGMENTS

Author thanks Dr. Josephine Laydia and Mr. Amir Khabazian Esfahani who assisted a lot in conducting this study.

REFERENCES

[1] A. Taleb Beidokhti, and M.B. Sobhani, “Social capital and economic development”, Academic Conference on Social Capital and Economic Development, Semnan University, 2009.

[2] M.G. Nateghpour, and A. Firuzabadi, “Social capital and the effective factors on its formation in Tehran City”, Iranian Journal of Sociology, vol. 4, 2006.

[3] S. Khorshid, and S. Darbandi, “Comparative study of social capital in public banks in Kerman City”, Journal of Knowledge and Development, vol. 32, 2011.

[4] H. Nikche Farahani, and GH. Nazaripour, “Role of social capital in labor force productivity”, Tadbir Monthly Magazine, vol. 202, 2009.

[5] F. Emamgholi, “Role of social capital in organizational performance (Case study: Management of Tejarat bank branches in Qazvin province)”, Journal of Management and Transformation, vol.7, pp. 59-67, 2011.

[6] M. Alvani, and A. Shirvani, “Social capital is the basic principle of development”, Tehran, 2006.

[7] GH. Taleghani, M. Tanaomi, A. Farhangi, and M. Zarin Negar, “Exploring the effective factors on increasing of productivity”, Public Management, vol.7, 2012.

[8] A. Ebrahimzade, M. Zare, and H. Esmaeilzade, "Exploring the role and importance of social capital in urban economic dynamism by emphasizing good urban governorship (Case study: Zahedan metropoliss)", The Conference on Urban Economy in Iran, 2012.
[9] F. Mehrabian, A. Nasiripour, and S. Keshavarz Mohamadian, "Investigation of the importance of the identified components of labor force productivity from the viewpoint of employees and faculty members of Guilan University of Medical Sciences", Scientific Research Journal of Zanjan, University of Medical Sciences, vol.75, pp. 94-106, 2011.
[10] Y. Ahmadi, and A. Mohammadi Bolbolan Abad, "Exploring the relationship between social capital dimensions and organizational citizenship behavior (Case study: Employees of customs duties in Kordistan province)", Social Sciences Journal of Islamic Azad University, Shushtar branch, vol. 2, pp. 153-178, 2014.
[11] KH. Khezrpour, M. Maziari, and R. Sabunchi, "Relationship between social capital and productivity of employees of Departments of Sports and Youth Affairs in West Azerbaijan province", Journal of Human Resource Management in Sport, vol.1, pp. 69-79, 2015.
[12] A. Bakhtiari, "Productivity of faculty members of Hamedan Payame Noor University with emphasis on the role of social capital", International Research Journal of Applied and Basic Sciences, vol. 13, pp. 955-961, 2015.
[13] A. Vafaee-Najar, M. Ghaemnejad, and S. Abbasi, 2014. "Relationship between social capital and nurses performance in hospital of Mashhad city", International Journal of Travel Medical Globe Health, vol. 3, pp.111-114, Iran, 2014.
[14] B. Pourghorban, M. Malekmohammadi, and R. Samei, 2015. "The relationship among intellectual capital, social capital and human resources productivity of staff in Sepah Bank branches, Golestan Province", International Research Journal of Management Sciences, vol. 1, pp. 19-23, Iran, 2015.
[15] F. Sabatini, "Does social capital improve labor productivity in small and medium enterprises"? International Journal of Management and Decision Making, vol. 5, pp. 454-480, 2008.
[16] A. Greve, M. Benassi, and A. Sti, "Exploring the contributions of human and social capital to productivity", International Review of Sociology, vol. 1, pp. 35-58, 2010.
[17] M. Salaran, "Research productivity and social capital in Australian higher education", Higher Education Quarterly, vol. 2, pp.133-148, 2010.
[18] F. Vincenzo, D. Mascia, "Social capital in project-based organizations: Its role, structure, and impact on project performance", International Journal of Project Management, vol. 30, pp. 5-15, 2012.
[19] CH. Chuang, SH. Chen, and CW. Chuang, "Human resource management practices and organizational social capital: The role of industrial characteristics", Journal of Business Research, vol. 66, pp. 678-687, 2013.
[20] M. Delmas, and S. Pekovic, "The engaged organization: Human capital, social capital, green capital and labor productivity", Academy of Management, pp. 111-116, 2013.
[21] K. Misra, PW. Grimes, and K. Rogers, "The effects of community social capital on school performance: A spatial approach", Journal of Socio-Economics, vol. 42, pp. 106-111, 2013.
[22] J. Nahapiet, and S. Ghoshal, "Social capital intellectual capital and the organizational advantage", Academy of management Review, vol. 232, 1998.
[23] H. Hersey, and M. Goldsmith, "A situational approach to performance planning", Training and Development Journal, vol.11, pp. 38, Madison, 1980.

★★★

THE EFFECT OF INTERNAL AND EXTERNAL MARKET ORIENTATION ON PERFORMANCE OF PUBLIC FIRMS IN IRAN

[1]MOJTABA MOLAAHMADI, [2]MORTEZA RAEI DEHAGHI

[1,2]Department of Management, Dehagh Branch, Islamic Azad University, Dehagh, Isfahan, Iran.
E-mail: [1] manager@iaudehagh.ac.ir, [2]dr_mraeidehaghi@yahoo.com.ph

Abstract- The present study seeks to investigate the effect of internal and external market orientation on financial and non-financial performance. It is applicable from objective aspect and descriptive-field from methodological aspect. The data was collected through documentary study and field study including questionnaire. All managers, deputies and experts of firms related to Shiraz Municipality equal to 1704 were the statistical population of the study during the time period April-December 2014. The sample size was estimated equal to 129 by means of random sampling method. Results of regression test indicated the positive effect of internal and external market orientation on financial and non-financial performance of firms related to Shiraz Municipality. According to the results, information production, information dissemination and how to respond to internal information have a positive and significant effect on financial and non-financial performance. Similarly, information production, information dissemination and how to respond to external information have a positive and significant effect on financial and non-financial performance.

Keywords- Financial Performance, Non-financial Performance, Market Orientation, Information Production, Information Dissemination, Respond to Information

I. INTRODUCTION

Market orientation entered the marketing literature since the 1980's. It is a concept that roots in marketing theory for the concept of marketing philosophy and has seriously been studied by Narver and Slater [1]. They introduced market orientation as the beating heart of modern management and marketing. According to them, market orientation is an organizational culture that provides the essential behaviors in order to create higher value for customers with the highest level of efficiency and effectiveness. It leads to superior performance and competitive advantage for businesses.

From the viewpoint of modern managers, marketing includes customer growth, i.e. paying attention to satisfaction and quality from customer's viewpoint and customer loyalty and effective relationship with the customer. As a result, firms try to have loyal customers. Paying no attention to the customer destroys any business. Therefore, market orientation is the prerequisite for successful operations of a business. Firms can create more value for consumers by paying attention to market orientation and innovation and enhance customer loyalty. This enables the firm to achieve competitive advantage in comparison with other firms and thus, obtains a better performance than its competitors.

II. STATEMENT OF THE PROBLEM

Market orientation is to create intelligence across the firm in relation with the current and future needs of customers among various sectors of a firm and general responding to that intelligence. It is both considerable inside and outside the firm as well as in domestic and international markets of a country [2].

However, it seems that focusing on external customer is not efficient to achieve organizational purposes and other objectives. If employees do not have customer-oriented attitudes and behaviors and if internal systems and processes are not focused on customer purposes, marketing methods that are exclusively used for external customers are probably facing with failures [3].

Hence, a balanced viewpoint should be considered especially by taking into account the relative importance of dimensions of internal and external market orientation in performance. The primary purpose of this study is to investigate the effect of each dimension of external market orientation on firm's performance regarding public sector administration from an integrated viewpoint. Most studies are mainly focused on total measurement of (internal/external) market orientation and have shown less attention to the effect of each component of market orientation on organizational performance. Second, this study seeks to investigate the effect of these components on both dimensions of financial and non-financial performance, because one-dimensional exploration of performance cannot give accurate results to beneficiaries. Thus, the major research question is proposed in this way: Are the components of internal and external market orientation able to influence financial and non-financial performance of firms?

III. SIGNIFICANCE OF THE STUDY

Due to the advancement and transitions of the information and communications technology major changes have occurred in recent decades in markets and have made companies and firms think about strategies to enhance their capability and maintain their competitive ability. One of the critical success

factors in the competitive world and maintenance of firms' survival is the capability for successful marketing of products and services. Marketing can be helpful in directing the purposes, strategies, and programs of firms and provides the possibility to achieve superior performance and a higher market share. Businesses have to enhance their marketing capabilities in order to achieve superiority against their competitors and attract and keep their customers. In other words, it can be stated that innovation has been determined as the condition for durability in any market through intensification of the competitive environment with the prerequisite of accepting the principle of competition. It has been led to the importance of market orientation instead of product-orientation. At the beginning of the 21st century, quick and total global changes have transformed the environment of firms' activities so that the firms and their managers have to find new ways for compatibility with the global changes and be able to remain in the internal and external competitive arena [4].

Dimensions of internal and external market orientation were considered in this study, because despite the numerous studies about the effect of market orientation on performance, the effect of individual dimensions of internal and external market orientation on performance has not been mentioned. Effects of implementing market-based behaviors in the framework of local public firms are explored in the present study. The balance between internal and external market orientation provides a unique opportunity for the firms in the public sector to achieve their mission and improve their performance.

Analysis of the effect of dimensions of internal and external market orientation on organizational performance is investigated in this study. Internal market orientation perspective is studied in order to help employees understand the organization better, foster their services in the organization, and adapt themselves with the organizational methods and change for the better. In this way, employees are prepared to confront with external factors and environmental challenges and enhance the success of the firm [3].

IV. THEORETICAL FRAMEWORK

Each study needs a theoretical framework. It is a model based on which the researcher hypothesizes about the relations among the important factors in creating a problem. It should not necessarily be the researcher's remark; in most cases, combination of the researcher's logical beliefs with the related research studies about the research problem has a key role in creating a basis to investigate the issue under study. In brief, theoretical framework deals with the relationship among independent, intervening, moderating and dependent variables that are supposed to be effective on the response and solution of the research problem. Creating such theoretical framework for formulation and testing of hypotheses as well as completing the researcher's understanding of the research problem are very helpful [5]. The theoretical framework of this study is displayed Fig. 1.

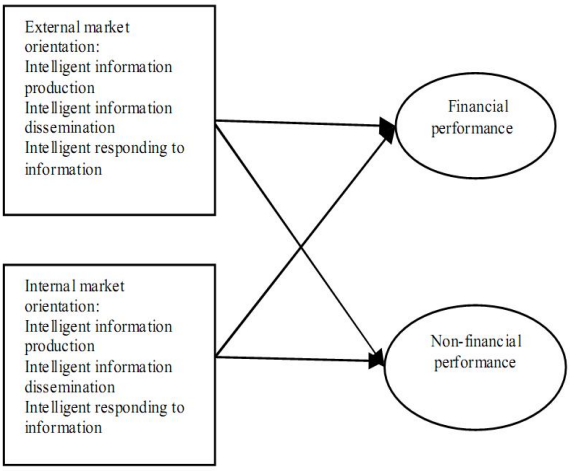

Fig. 1. Conceptual framework of the study (source: Rodrigues & Pinho, 2011)

V. LITERATURE REVIEW

Several studies have been conducted about internal and external market orientation and their consequences. Among these studies, the below cases can at least be mentioned. In an article entitled "the effect of internal and external market orientation on public firms' performance in Portugal" Rodrigues and Pinho (2011) showed that external information distribution and respond to information are strongly effective on non-financial performance and external information production and respond to information have a positive effect on financial performance. But with regard to internal market orientation, the results do not show a lower effect on performance.

Subramanian [6] explored the relationship between market orientation and business performance in 159 intensive care units in the US. The results of his study showed a positive relationship between market orientation and business performance in intensive care units.

Tsiotsou [7] investigated the relationship between market orientation and service performance in 329 tourism industries in Greece and Lithonia. According to the results, there was a direct relationship between customer orientation and service performance and indirect relationship between competitor-orientation, cross-sectoral coordination and service performance.

In a paper entitled "Is market-orientation a resource for achieving competitive advantage in firms?" Kumar et al. [8]) collected data during nine years of activity of 261 firms in the time period 1997-2005. The results of their paper disclosed that the firms which emphasized and performed market orientated activities had a better performance and competitive advantage than other firms.

Merlo and Auh [9] investigated the relationship between market orientation, role of entrepreneurship and influence of the secondary unit of marketing with business performance in 600 medium and large manufacturing enterprises in Australia. The results showed that there was a slight relationship between market orientation and role of entrepreneurship with business performance. Mohammad Karimi and Khosravi [10] presented an article entitled "the role of market orientation in the relationship between internal marketing and bank performance. According to the results, internal marketing had a positive effect on market orientation and in turn, market orientation had a positive effect on performance. Likewise, internal marketing had a positive effect on performance through the intermediary variable of market orientation indirectly. But no relationship was observed between internal marketing and performance directly. Moreover, each component of internal marketing had a positive effect on both components of market orientation. In an article entitled "exploring the effect of internal marketing on market orientation in service organizations", Hassangholipour et al. [11] performed a field study in Bank Mellat in Tehran City by emphasizing the intermediary role of organizational citizenship behaviors and organizational commitment. According to the findings, there was a positive relationship between internal marketing and market orientation in Bank Mellat. Also, there was a positive relationship between internal marketing and organizational commitment in Bank Mellat as well as between internal marketing and organizational citizenship behaviors. In addition, there was a positive relationship between organizational commitment and market orientation and between organizational citizenship behaviors and market orientation in the above bank. Pakdel et al. [12] carried out a study entitled "evaluation of the effect of market orientation, innovation and customer loyalty on business performance (case study: Pol clothing group)". Data analysis and testing of hypotheses indicated that increased level of innovation in Pol clothing group is the result of increased level of market orientation and this led to a better innovation performance in the firm. Increased loyalty of customers is resulted in the growth of innovative performance of the firm and finally the level of business performance is enhanced. Numerous studies have been conducted about the effect of internal and external market orientation on financial and non-financial performance among which we can mention Zhou et al. [13], Chen and Quester[14], Hsieh et al. [15], Micheels and Gow [16], Hamidizade and Ghamkhari [17], Arasti et al. [18], and Heidarzade [19].

VI. METHODOLOGY

This study is descriptive-field-correlational in which documentary study and field study were used to collect the information related to theoretical principles and theoretical background of the research topic.

6.1. Statistical population

All managers, deputies and experts of the firms related to Shiraz Municipality equal to 1704 were the statistical population of the study in 2014.

5.2. Sample and sample method

In order to determine the sample size, a preliminary study was conducted on 30 persons because variance of the statistical population was inaccessible. Then the sample size was determined equal to 129 through Cochran formula.

5.3. Data collection method, Tools and Analysis

The required data was collected through documentary study and questionnaire. Rodrigues and Pinho's standard questionnaire (2011) was employed and the Likert scale was utilized to extract the opinions. Descriptive statistics methods were used to analyze descriptive data. Kolmogorov-Smirnov test, variance analysis and regression and Friedman test were employed for data analysis by means of SPSS-20 software.

VII. FINDINGS

In this section, hypotheses were tested using Pearson correlation test and regression analysis. The results are shown in Tables 1 and 2. Analyses were done through SPSS-20 software.

7.1. The main hypothesis

Internal and external market orientation has a direct and positive effect on financial and non-financial performance. This hypothesis was tested through simple regression test. The results are shown in Tables 1 and 2. The significance level related to F test is less than 0.05; thus this hypothesis is accepted and it can be stated that internal and external market orientation has a direct and positive effect on financial and non-financial performance.

Table 1. Regression results about financial and non-financial performance in terms of internal and external market orientation

Model		Constant	Internal and external market orientation
Raw coefficients	B	2.394	0.426
Standard coefficients	Standard error	0.393	0.104
	Beta		0.340
T		6.085	4.097
Significance level		0.000	0.000

Table 2. Indexes of the regression model of financial and non-financial performance in terms of internal and external market orientation

Significance level	0.000
F	16.782
Adjusted coefficient of determination	0.109
Coefficient of determination	0.116
The square root of coefficient of determination	0.340

Adjusted coefficient of determination of this model is equal to 0.109. Hence, 10.9 percent of changes of financial and non-financial performance can be explained by internal and external market orientation. The below equation can be presented to predict the changes of financial and non-financial performance based on internal and external market orientation:

(1) Financial and non-financial performance= 2.394 + (0.426) internal and external market orientation

According to above equation number (1), 0.426 units are added to financial and non-financial performance in lieu of one unit increase in internal and external market orientation. Given the adjusted coefficient of determination, degree of effectiveness of internal and external market orientation on financial and non-financial performance is 10.9%.

DISCUSSION AND CONCLUSION

The purpose of this study was to investigate the effect of internal and external market orientation on financial and non-financial performance in firms related to Shiraz Municipality. It is applicable from objective aspect and descriptive-field from methodological aspect. All managers, deputies and experts of firms related to Shiraz Municipality, equal to 1704, were the statistical population of the study. The sample size was determined equal to 129 by means of Cochran formula. Results of regression test between the independent variables (internal and external market orientation) and the dependent variable (financial and non-financial performance) show that there is a positive and significant correlation between the two variables. The significance level is less than 0.05. Given the adjusted coefficient of determination, the effect of internal and external market orientation on financial and non-financial performance is 10.9 percent (low-moderate) and beta coefficient is equal to 0.426. It means that 0.426 units are added to financial and non-financial performance of firms related to Shiraz Municipality in lieu of one unit increase in internal and external market orientation. Therefore, the major hypothesis regarding that internal and external market orientation has a significant effect on financial and non-financial performance is confirmed.

ACKNOWLEDGMENTS

Author thanks Dr. Josephine Laydia and Mrs. Neda Jamshidi who assisted a lot in conducting this study.

REFERENCES

[1]. [1] J.C. Narver, and S.F. Slater, “The effect of a market orientation on business profitability”, Journal of Marketing, vol. 54, pp. 20– 35, 1989.

[2]. [2] A. Divandari, R. Seyed Javadin, M. Nahavandian, and H. Aghazade, “Exploring the relationship between market orientation and performance of Tejarat Banks in Iran”, Journal of Business Management, vol. 2, pp. 15-25, 2009.

[3]. [3] A.P. Rodriguez, and J.C. Pinho, (2011). “The impact of internal and external market orientation on performance in local public organisations”, Marketing Intelligence & Planning, vol. 30(3), pp. 284-306, 2011.

[4]. [4] T. Feizi, “Principles of organization and management”, Tehran, Payame Noor University, 2008.

[5]. [5] GH. Khaki, (2009). “Business research methods”, Publications of the Islamic Azad University, Tehran, 2009.

[6]. [6] R. Subramanian, K. Kumar, and K. Strandholm, (2010). “The role organization competencies in the market orientation- performance relationship”, International Journal of Commerce and Management, vol. 19(1), pp. 7-26, 2010.

[7]. [7] R.H. Tsiotsou, (2010). “Delineating the effect of market orientation on services performance: A component-wise approach”, The Service Industries Journal, vol. 30(3), pp. 375-403, 2010.

[8]. [8] K. Kumar, R. Subramanian, and C. Yauger, (2010). “Examining the market orientation- performance relationship: A context-specific study”, Journal of Management, vol. 24, 2010.

[9]. [9] O. Merlo, S. Auh, (2009). “The effects of entrepreneurial orientation market orientation and marketing subunit influence on firm performance”, Market Letter, vol. 20, pp. 295-311, 2009.

[10]. [10] P. Mohammad Karimi, and A. Khosravi, (2013). “Role of market orientation in the relationship between internal marketing and bank performance”, Proceedings of the Fourth International Conference on Bank Services Marketing. Tehran, IRIB International Conference Center, 2013.

[11]. [11] T. Hassangholipour, M. Ansari, and A. Elahigol, (2012). “Exploring the effect of internal and external market orientation in service organizations by emphasizing the intermediary role of organizational citizenship behaviors and organizational commitment in Bank Mellat in Tehran City”, Journal of Business Management, vol. 11, pp. 39-54, 2012.

[12]. [12] M.R. Pakdel, SH. Nayebzade, H. Dehghan Dehnavi, “Evaluation of the effect of market orientation, innovation and customer loyalty on business performance (case study: Pol clothing group)”, Journal of Marketing Management, vol. 10, pp. 78-90, 2012.

[13]. [13] A. Goo, A. Millan, A. Molina, and K. Martin, “Market orientation in service: A review and analysis”, European Journal of Marketing, vol. 36(9-10), pp. 1003-1021, 2009.

[14]. [14] S.C. Chen, P. Quester, “Modeling store loyalty: perceived value in market orientation practice”, Journal of Services Marketing, vol. 20(3), pp. 188-198, 2009.

[15]. [15] J. Hesiye, L.L. Callarisa, R.M. Rodriguez, and M.A. Moliner, “Perceived value of the purchase of a tourism product”, Tourism Management, vol. 27(4), pp. 394-409, 2008.

[16]. [16] A. Micheels, T. Eric, R. Gow and B. Hamish, “Market orientation, innovation and entrepreneurship: An empirical examination of the Illinois Beef Industry”, International Food and Agribusiness Management Review, vol. 11(3), 2008.

[17]. [17] M.R. Hamidizade, M. Ghamkhari, (2010). “Identification of the effective factors on customer loyalty based on the fast-response organization model”, Iranian Journal of Trade Studies, vol. 5, pp. 187-202, 2010.

[18]. [18] M.R. Arasti, A. Karamipour, and B. Ghoreishi, “Identification of the effective factors on innovation capacity of economic firms (case study: Industrial automation companies in Iran)”, Iranian Journal of Management Sciences, vol. 15, pp. 57-65, 2010.

[19]. [19] K. Heidarzade, D. Hosseini Radfar, “Exploring inter-personal relations and their effect on customer satisfaction and loyalty towards service provider”, Marketing Management Research Journal of the Islamic Azad University, Science and Research Branch, vol. 4, pp. 34-44, Tehran, 2008.

★★★

THE GRAIN SIZE DISTRIBUTION OF SANDY SOILS IN LIBYA

MASSOUD FARAG ABOUKLAISH

Associate Professor, Faculty of Engineering and Technology Science, Sebha University, Libya

Abstract- Where that all types of soil consists of grains in different sizes, and these grains can be obtained and identified by knowing the results of grain size distribution of the soil tests. The results of grain composition of the soil are the basis for the classification and be very useful in obtaining some characteristics of the soil. So the main aim of the present study is to investigate and classify the particle size distribution of sandy soils in Libya. More than fifty soil samples collected from many regions, North, West and South of Libya. Laboratory sieve analysis tests performed on disturbed soil samples. As well as to provide an indicator of general engineering behaviour and good understanding, test results are presented and analysed, some of the significant parameters such as the gradation parameters and grain diameters for these types of soil have been identified, also found links between some of these parameters. Soil classification based on particle size analysis(USCS) is used. In addition, conclusions, recommendations are made.

Key words- Grain size distribution of soils, Sieve analysis tests, Soil classification.

I. INTRODUCTION

When measuring grain size distribution of soil grains larger than(0.075mm) sieving analysis is used. The grain size distribution of a soil is defined as the relationship between per cent passing (by mass) and the particle size. The particle size represents the size of particles that can pass a particular sieve mesh. The per cent passing represents the mass percentage of particles passing a particular sieve size. There are three primary types of grain size distributions[6]. These three types of distributions are known as well-graded soils, uniform soils, and gab graded soils. The grain size distribution for a soil provides several benefits, to classify soils, to estimate soil properties. Many researchers have studied the grain size distribution of the soil types and pointed to its importance[1), 4), 7)]. The range of particle sizes can be found out from the gradation curve. Soil gradation is a classification of a coarse-grained soil; soil gradation is an important aspect of soil mechanics because it is an indicator of many engineering properties of soils, such as compressibility, shear strength, permeability, etc. The good understanding of grain size distribution of the soils is important for the wide use of soil in many civil engineering works, several useful parameters and mathematical correlations can be determined from grain size distribution curves. Due to the presence of sandy soils in Libya[2),3)]. This study therefore focused on the determination of grain size distribution of the sandy soils of the mentioned regions in order to classify and to better understand their particle size distribution.

II. STUDIED AREAS AND SOIL SAMPLES

Areas where soil samples were taken included the north and west and the south of Libya as shown in table 1. From selected depths in soil layers at each site, sandy soil samples were taken from a depth of a bout 1m to 3m below the ground surface. The top soil layers at the studied areas consist of sandy layers extent to a depth of more than 5m below the ground level. The ground water table at all the sites is located below the studied soil layers.

Table1. Soil Samples Sites

North Regions- Libya	West Regions- Libya	South Regions- Libya
Tripoli, Janzur, AL Zahra, Al Saraj, Tajoura.	Zawia, Surman, Subratah, Al Ajellat.	Sebha, Brack, Murzuk, Tahalla, Takarkeyba, Algufra, Gat, Al abead.

III. EXPERIMENTAL RESULTS AND DISCUSSIONS

For the purpose of experimental investigations more than fifty samples of sandy soils were prepared in the laboratory. It was found out that all the soil samples were non-plastic. The grain size distribution analysis involving mechanical analysis was carried out. And the results of ten samples from each site are presented as shown in Figures (1), (2) and (3). The test results showed that all the soil samples do not have clay and the small percentage of silt as well as some of the very small percentage of gravel, and classified as poorly graded soils.

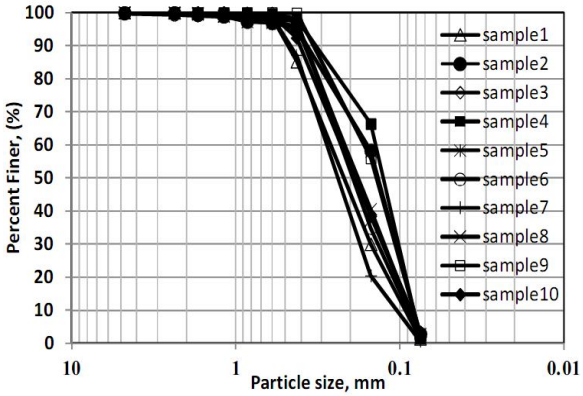

FIG.1. Particle Size Distribution Curves of the North Samples

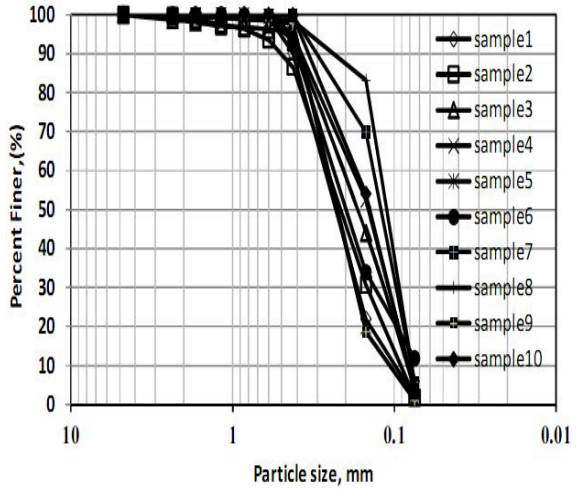

FIG.2. Particle Size Distribution Curves of the West Samples

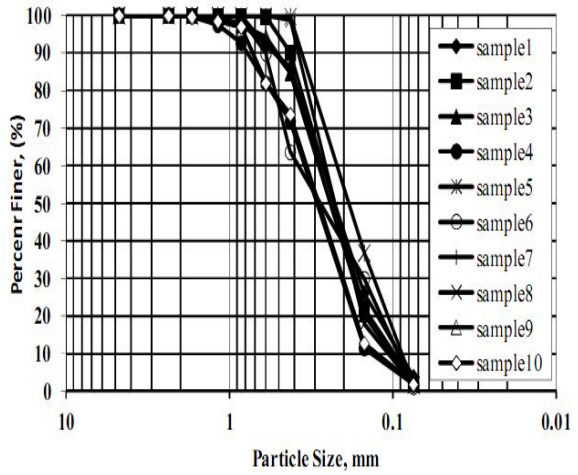

FIG.3. Particle Size Distribution Curves of the South Samples

The relations between the uniformity coefficient and the particle sizes, d50, d60 and d85 of the tested soils as have shown in Figures (4), (5) and (6). From these relations, one may observed a linear relation between uniformity coefficient and these particle sizes, the uniformity coefficient values ranging from 1.35 to 3.30 for all the tested soils from different regions.

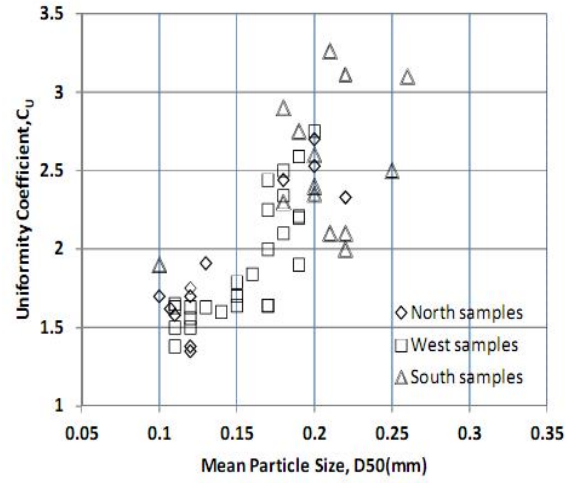

FIG.4. Relationship between Uniformity Coefficient and Mean Particle Size, D50

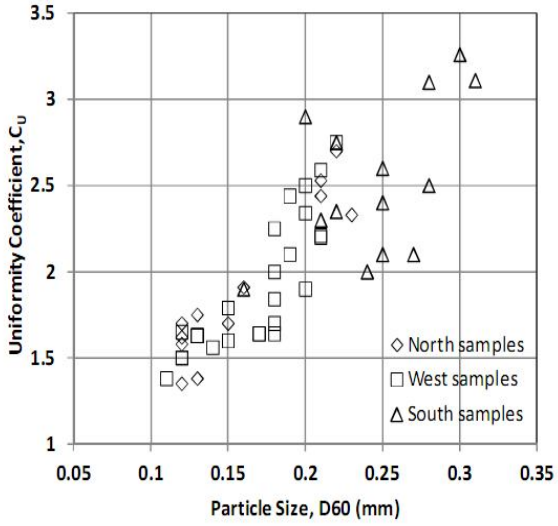

FIG.5. Relationship between Uniformity Coefficient and Particle size, D60

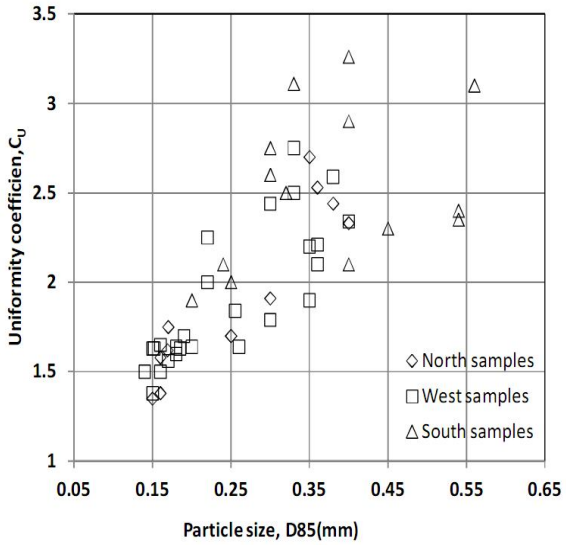

FIG.6. Relationship between Uniformity Coefficient and Particle size, D85

CONCLUSIONS

The following conclusions are drowned from the present research and can be summarized in the following main points:

1. The results of this investigation indicated that the grain size distribution of sandy soils from many regions in Libya is similar.
2. The test results and observations showed that all the tested sandy soils do not have clay and the small percentage of silt as well as some of the very small percentage of gravel.
3. The results of a series of grain size analysis and classification of sandy soils from many regions in Libya indicate poorly graded sandy soils.
4. Fine-grained sandy soils exist in many parts of Libya and at different depths below the ground surface.
5. Several useful parameters can be determined from grain size distribution curves.

6. The uniformity coefficient of the studied sandy soils increases with increasing the mean particle size (d50), particle size (d60) and particle size (d85).
7. The uniformity coefficient values of the studied sandy soils ranging between "1.35 to 3.30" which indicate poorly graded soils.
8. The particle size values of the tested sandy soils ranging as follows: d10 ranging from 0.06mm to 0.13mm, d50 ranging from 0.10mm to 0.26mm, d60 ranging from 0.10mm to 0.31mm and d85 ranging from 0.14 mm to 0.60mm.

RECOMMENDATIONS

I would recommend an increase research on these types of sandy soils to learn about the different engineering characteristics and find a guide to help identify them before they are used in various field of civil engineering.

REFERENCES

[1]. Folk RL.(1966). "A review of grain-size parameters". Sedimentology 6:73-93.

[2]. K.R. Ben Mahmoud and G.M. Abdulgawad.(1995). "Nature and properties of selected desert soils of the Fezzan area of Libya". Journal of Basic and applied scientific, National Academy of scientific Research, Issue No.1-3rd, Tripoli.

[3]. Massoud F. Abouklaish.(2013). " Some of the Physical properties of sandy soils in Libya". Twelfth Arab Structural Engineering Conference, Tripoli, Libya.

[4]. Mc Manus J.(1988)." Grain size determination". In Techniques in Sedimentology, Tucker M(ed.). Blackwell: Oxford, 63-85.

[5]. Bui EN, Mazullo J, Wilding LP.(1990). "Using quartiz grain size and shape analysis to distinguish between Aeolian and fluvial deposits in the Dallol Bosso of Niger(West Africa)". Earth surface Processes and Landforms 14:157-166.

[6]. Holtz, R. and Kovacs, W.(1981). " An Introduction to Geotechnical Engineering", Prentice-Hall, Inc. ISBN0-13-48439-0.

[7]. M.S. Nouaouria, A. Rouiguia and I. Jefferson.(2003). "Engineering Properties of Loess in Algeria", 1st International Conference of Civil Engineering Science, ICCES1, vol.1.

[8]. American Society for Testing and Materials (ASTM).

★★★

MOTIVATION SERVING CUSTOMERS AS DETERMINANTS ESTABLISHED OF ENTREPRENEURS BEHAVIOUR OF SMES IN INDONESIA

[1]ANDREAS FK, [2]SASMOKO, [3]ARNOLD TINDAS, [4]FREDERIKUS FIOS

[1,3]Harvest International Theological Seminary; [2,4]Bina Nusantara University
E-mail: [1]andreas@andreasfk.com, [2]sasmoko@binus.edu, [3]arnoldtindas@gmail.com, [4]fios@binus.ac.id

Abstract- Micro, Small and Medium Enterprises (SMEs) are businesses engaged in various business sectors and touch the people's interests in Indonesia. This business population is about 42.5 million units (99.9%) of all businesses. SMEs provide a significant contribution to employment (99.6%) and give significant contribute to Gross Domestic Product amounted to 56.7%. It turns out this great potential allegedly not accompanied by good behavior of businessman. This study wanted to know the role of consumers serving motivational as a determinant of business behavior established of SMEs in Indonesia. The research covers all SMEs in Indonesia. The study took place between August 2015 to March 2016. The research method uses Neuro-Research (mix-method) that combines qualitative research (exploratory) and quantitative (explanatory and confirmatory). The research sample of 700 entrepreneurs of 25 cities. Sampling techniques uses Multystage Sampling. Results: (1) SMEs in Indonesia are likely to have a good business behavior significantly at $\alpha<0.05$; (2) analysis with Binary Segmentation (Classification and Regression Trees), prunning namely Depth by 2, Parent amounted to 2, and Child by 1, a significance level of $\alpha<0.05$. Increasingly entrepreneurs of SMEs in Indonesia have best motivation to serve consumers (X), then the behavior of entrepreneurs in doing business (Y) will be improved 31.449 times. Suggestions: (1) the government should realize the new policy namely "the realization of best motivation serving customers to improve fanaticism customers in order to force changes in the behavior of business entrepreneurs of SMEs in Indonesia, and (2) the government should build a Service Center for Entrepreneurial SMEs in every city across Indonesia as a consultant and companion SMEs to be able to plan the business, build business organizations, running a business with good governance, and maximize marketing product.

Index Terms- Neuro-Research, Motivation Serving, Customer, Entrepreneurs Behavior

I. INTRODUCTION

Humans are the subject once economic actors who do relationships with others (customers) to do business and develop the welfare quality of life for the better future. Success or failure is determined by the economic actors fundamental elements that affect it. The subject of economics is that the entrepreneur or small and medium businesses who conduct activities in the business world. Improving the quality of business an economic agent (entrepreneur) is determined by many factors that determine the success or failure of businesses plan. These factors are, among others: the behavior of entrepreneurs, motivation in serving customers, and a good attitude in entrepreneurship. This study aim to prove how the trends in entrepreneurship of the SMEs in Indonesia? Which factors are the most influence to the success of SMEs in doing entrepreneurship in Indonesia?

II. THEORETICAL REVIEW

Many studies have been done related to the theme of this entrepreneurship topic. Studies conducted by Van Auken, Howard, Ritternburg, Terri, Doran , and Fang (1994) says "Woman enterpreneurs obtained information concerning reviews their use of advertising media during reviews their first and most current years of operantions. Woman using advertising media for developing their bussiness. The findings are consistent with a previous survey of small business owners, the which indicated resources that the use of advertising media during the first year of operation appeared to be the key determinant of its usage in the current year. One difference found in the current study was that a higher percentage of woman enterpreneurs using refferals, community events, the telephone directory, and fliers than by the sample were in the previous study.[1]

Esin (2011) conducted a study entitled "The decriptive analysis of the problems of woman enterpreneuners". In this paper, it is studied that the problems of women entrepreneurs in business life and society in Aydin Province, in comparison with the man entrepreneurs, the recognition of Aydin Business Women Association and the initiatives to support women entrepreneurs. In the methodology part, survey research is applied to women Entrepreneurs in Aydin. The descriptive statistics concerning about the women entrepreneurs, the environment, Aydýn Business Women Association, and the problems on both micro and macro level are analyzed. In the conclusion part, as a response to statistical results, possible solutions to enable improvements in the future are presented by determining the problems of women entrepreneurs.[2]

Ivanovic, Rot, Pretula (2013) examines intrepreneurship in Croatia. After introductory explanations regarding the selection problems of

small enterprises in the Croatian hotel industry, the author provides a number of key indicators of their role in improving the competitiveness of the Croatian hotel industry in the global tourism market. In developed tourism countries, small enterprises have a dominant share in the structure of the hotel industry, and their importance is growing even in the former socialist countries of Europe. Small hotels in Italy accounted for more than 50%, and in Austria with more than 70% of lodging facilities and represent a generator of hotel business in a large number of European tourism countries, and great attention is given to the small enterpreneurs stimulating their growth with different measures of tourist and general economy politics. The author reflects on the Croatian experience of the small businesses in the hospitality through research of development of small family hotels and their importance for the improvement of the supply of the Croatian hotel industry which future is built on personal approach to guests and present trends in the tourism market. States that the role of the National Association of family and small hotels, which represents the specific interests of small hoteliers and enables the continuous improvement of the quality of their offerings, as well as measures to encourage small business development at the macro level. Based on the made analysis the measures of increasing the efficiency of small businesses in the Croatian hospitality are given.[3]

Ramli, Samah, Hassan, Omar, Bolong (2015) examines "Potential Benefits of ICT for Youth Agro-based Entrepreneurs in Malaysia". Information Communication Technology (ICT) offers an abundance of benefits to users, particularly in relation to socio-economic aspects. Agro-based entrepreneurs are one group of users that has experienced such benefits. Additionally, young agro-based entrepreneurs are able to access more opportunities due to their superior ICT knowledge and compatibility. The present study aims to identify the potential benefits of ICT usage for youth agro-based entrepreneurs. Through document analyses, it can be concluded that the benefits offered from ICT to youth agro-based entrepreneurs include improving operational efficiency, increasing income, strengthening marketing aspects and creating new opportunities. With all of these potential benefits in place, it is hoped that consistent involvement from youths in the agriculture industries can be ensured.[4]

The attitude of serving motivation is very important to increase the success of the business done by the entrepreneurs to consumers. Achampong and Zemedkun (1995) makes empirical research and ethical analysis of the factors that affect the company managers in making decisions. This study examines the role of managerial self-interest in the merger market. The same factors are examined for acquiring, acquired, and merging firms, and control groups used in each case. Results support the authors' contention that managerial discretion is a significant motivating factor for mergers. The changes in expense preference factors indicate management decisions which provide conditions allowing management to indulge in management preferred expenditures, while reducing risk to their careers. A moral/philosophic framework of ethical analysis is provided for examining managers' merger decisions using teleological and deontological theories. It is concluded that merger decisions motivated or influenced by self-interest are unethical.[5] Morrall (1996) emphasized the importance of increasing the motivation of the sales staff with a reward. An effective sales reward program depends on understanding what motives employees and tying the rewards to the overall goals of the bank. Implementing successful incentive programs involves good communication, timely recognition, reinforcement of desired behavior and accountability and measurement of results. Strong sales cultures emerge for reward programs that recognize both individual and team performance.[6] A. Marcus Williams (2008) show the importance of high motivation in service to consumers performed by black entrepreneurs.[7] Berenson and Rice (2015) says that motivation is an important method of business that can enhance the image and market confidence to entrepreneurs. Berenson and Rice examines the effects of intangible extrinsic cues on consumer quality perception and purchase intention of private brands while quality variation reduces both outcomes. All effects of the three extrinsic cues on purchase intention are partially mediated by quality perception. Consumer value consciousness strengthens the relationship beetween quality perception and purchase intention of private brands.[8]

Good entrepreneurship attitude is urgently required in the business. Sajfert, Nikolic, Djordjevic, Atanaskovic (2009) conducted a study on the importance of entrepreneurship behavior among managers in Serbia. This research herein is to define the different life objective structures of managers and specialist in public enterprises. Owners of private enterprises-enterpreneurs were analyzed as a control group.The research proved that successful private owners-enterpreneurs, the capital ownners, have different structure of life objectives comparing to both managers and specialistsin public organizations.Since the enterpreneurs invested their private capital to realize their ideas, it is logical that they want their capital to be increased. Managers and specialists in public enterprises do not have such a great sense for capital increment. They rathter share the capital preferring to be sociable(clubs sponsors, great humanitarians. The reason for such behaviour can be found found in a fact that Serbia was influences by socialism which furtherresulted in pooreducation of

managers and specialists to change their way of thinking. Managers as well as specialists should become knowledge workers who shall exchange their knowledge.[9]

III. METHODS

This study aims to measure variables serving customers motivation as determinants of entrepreneurs established behaviour of SMEs in Indonesia. Place of research across the Small and Medium Enterprises (SMEs) in Indonesia on business macro sector. The time of study between August 2015 until the March 2016. The research method using Neuro-Research[10] (mix-method) is a mixure of qualitative research methods and quantitative methods. In the first stage, carried out by the method of exploratory research (qualitative) through a theoretical study of the behavior of ideal entrepreneurs of SMEs in Indonesia, serving consumer motivation, and good attitude creterias in entrepreneurship. The study aim to find a theoretical construct for the best context in Indonesia condition. The second stage, uses survey method that is both explanatory and confirmatory particular by deepening the results of exploratory research through quantitative research to find the most powerful shaper of the behavior of SME entrepreneurs in Indonesia context. Sample testing research instruments as much as 10 entrepreneurs. Average sample of 700 entrepreneurs. Mechanical sampling with multistage sampling. The first stage, the population is divided by area of Indonesia with cluster sampling consists of part of Indonesia Section West, Central and East of Indonesia. The second phase, each region of Indonesia have a minimum of 3 districts/cities with cluster sampling. The third stage, the selection of district/city each cluster defined by grouping the magnitude of the regional revenue source is derived from the revenue of SMEs with stratified sampling. The fourth stage, based on the districts/cities, then set the sample members are entrepreneurs at random. The results of the research sample includes 25 districts/cities: (1) Makassar, (2) Maluku (Ambon), (3) Bandung, (4) Denpasar, (5) Medan, (6) Tangerang City, (7) Palembang, (8) Pontianak, (9) Tenggarong, (10) Bogor, (11) Manado, (12) Balikpapan, (13) Madiun, (14) Sidoarjo, (15) Surabaya, (16) Kediri, (17) Banyuwangi, (18) Lampung, (19) Sorong, (20) Kupang, (21) Malang, (22) Jakarta, (23) Semarang, (24) Jember, and (25) Palu. All the instruments of research using large-scale data collection techniques Likert Scale Model with the data scale range 1 to 5. All the instruments proved to be valid by the Reliability Index instruments behavioral observation SME entrepreneurs in Indonesia amounted to 0.892. Motivation instruments Serve Customers of 0.876 and 0.866 for Entrepreneurship Attitudes instruments.

IV. RESULTS AND DISCUSSION

Hypothesis 1: Entrepreneurs SMEs in Indonesia Significantly Tend Good in Bahaviour. In proving, the researchers in this case the 3 (three) categories of the behaviour of SME entrepreneurs in Indonesia, namely: (a) unsympathetic behaves, (b) quite good behaves, and (c) polite behave. Data analysis was performed with confidence intervals at a significance level of 5%, and the resulting lower and upper bound between 52.6058 up to 56.7125. Based on these results, we can conclude that the entrepreneurs of SMEs in Indonesia tend to behave significantly better at $\alpha < 0.05$.

Hypothesis 2: Motivation Serve Customers Represents the Most Dominant Determining Variable behavior of entrepreneurs of SMEs in Indonesia. This analytical approach set with Binary Segmentation called Classification and Regression Trees. In this analysis, it was determined that his prunning Depth by 2 ; Parent amounted to 2 ; and Child by 1, with a significance level of $\alpha<0.05$. Summary results of the analysis as follows:

The study found that the Motivation of Serving Consumers (X_1) is the most dominant variable shape the behavior of entrepreneurs of SMEs in Indonesia (Y) . The more SME entrepreneurs of Indonesia improved its motivation in serving consumers (X_1), then the enterpreneurial behavior (Y) will be increased 31.449 times from the current state. Being on the other hand, if the attitude of Entrepreneurship (X_2) improved more better, then the motivation to serve customers (X_1) will increase 3.1185 times.
From the above results it can be said that the motivation to serve customers greatly affect the success of entrepreneurship in business. If serving consumer motivations and attitudes to entrepreneurship are equally enhanced synergistically, then the behavior of SME entrepreneurs in Indonesia will be formed with the ideal. It is important and urgent to sustain the existence of a group of entrepreneurs in Indonesia.

Especially in the context of the ASEAN Community, serving consumer demands for motivation and attitudes to entrepreneurship has become a necessity. The influx of foreign workers to the Indonesia and the motivation paradigm of good business attitude would threaten the existence of entrepreneurship in the country of Indonesia. Then the entrepreneur who survived and were able to adjust to the demands of motivation to serve consumers who will survive in this competitive conditions of ASEAN Community.

Change or die! Attitude prototype of entrepreneurs with high motivation in serving consumers becoming

a character, habits, living good attitude in life in the private entrepreneurs in Indonesia. It's time entrepreneurs struggle to organize themselves to transform the planning, production processes, product quality, marketing, entrepreneurial attitudes and behavior of SMEs oriented towards consumer services in ASEAN. Only in this way the product business generated business people get a place in the hearts of consumers in Indonesia in the country and abroad.

CONCLUSION

The conclussion are:

1. Entrepreneurs SMEs in Indonesia tend to behave significantly better at $\alpha < 0.05$.
2. Motivation Serve Customers (X1) Variable Represents the Most Dominant Shaping Behavior of Entrepreneurs of SMEs in Indonesia (Y) . Increasingly entrepreneurs of SMEs in Indonesia has the best serve consumers motivation (X1), then the enterpreneurial behavior (Y) will be increased by 31.449 times.

Some suggestions:

1. The Government should map out a new policy that is "the realization of increased motivation to serve to all customers with the best standards in order to increase consumer loyalty to Indonesia SME products that can compete at the level of ASEAN.
2. The Government, the private sector and civil society should define the new strategy to realize a new paradigm in entrepreneurship through the efforts "mentoring programmed and planned" to all the entrepreneurs of SMEs, so that the direction and progress of the business completely guided and measured. With the new paradigm, the entrepreneurs were able to respect themselves which are expanding and as a country is also able to measure the success of SMEs in contributing foreign exchange.
3. The government needs to build simultaneously "A Center for Integrating Entrepreneurial Mentoring SMEs" in each district/cities throughout Indonesia. His job is as a consultant and also a companion of SMEs, so that every SME that has grown and is being pioneered the SME is able to properly carry out the planning, building business organizations, do good corporate governance even up to the marketing of SME products.

REFERENCES

[1]. [1] Van Auken, Howard E. Rittenburg, Terri L. Doran, B. Michael (1994). “An Empirical Analysis of Advertising by Woman Enterpreneurs”. Journal of Small Business Management, Vol. 32, Issue 3, Pages 10-19.

[2]. [2]. Esin Sayin (2011). “The Descriptive Analysis of the Problems of Woman Enterpreneurs”. International Bibliography of the Social Sciences (IBSS), Vol. 3, Issue 1, pages 23-32.

[3]. [3]. Slobocan Ivanovic , Eddy Rot, Miroslav Pretula (2013). “Small Enterpreneurship in Hospitality: Croation Experiences”. UTMS Journal of Economics, Vol. 4.1, pages 27-35.

[4]. [4] Siti Aisyah Ramli, Abu Bahaman Samah, Salleh Md Hassan, Sitti Zobidah Omar, Jusang Bolong (2015). “Potential Benefits of ICT for Youth Agro-Based Enterpreneurs in Malaysia”. Journal of Applied Sciences, Vol. 15.3, pages 411-414.

[5]. [5] Francis A., Achampong and Wold Zemedkhun (1995). “An Empirical and Ethical Analysis of Factors Motivating Managers Merger Decission”. Journal of Business Ethics, Vol. 14, Issue 10, pages 855-865.

[6]. [6] Katherine Morrall (1996). Motivating Sales Staff with Rewards. Washington: American Bank Assoctiation, page 7.

[7]. [7]. Marcus A. William (2008). Biz Talk With Josh: Motivating the Black Enterpreneur. Washington: Afro-American Company of Baltimore City.

[8]. [8]. Robert A. Berenson and Thomas Rice (2015). “Beyond Measurement and Reward: Methods of Motivating Quality Improvement and Accountability”. Health Services Research, Vol. 50 Issue 6, pages 220-226.

[9]. [9]. Zvonko Sajfert, Milan Nikolic, Dejan Djordjevic, Predrag Atanaskovic (2009). “Research on Life Objective Structures of Managers and Enterpreneurs in Serbia”. International Bibliography of the Social Sciences (IBSS), Vol. 3, Issue 1, pages 78-105.

[10]. [10]. Sasmoko, Frederikus Fios, Syarifah Diana Permai. Neoru-Research Method. Jakarta: Bina Nusantara Publishing.

★★★

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

[1]C. BENACHAIBA, [2]B. MAZARI, [3]M. HABAB, [4]C. BENOUDJAFER, [5]N. M. TANDJAOUI

[1]Faculty of technologies and science, Bechar University, Algeria
[2]LDEE, Faculty of technologies and science, USTOran, Algeria
E-mail: chellali@netscape.net

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:

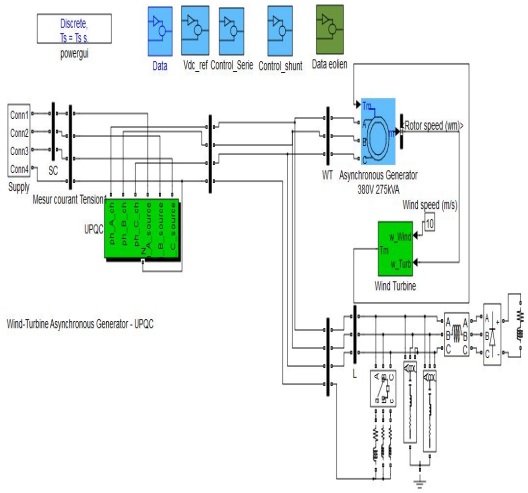

Fig. 1 The simulated system

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

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

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

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

where, P_t [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], w is the rotational speed [rad/s], Cp 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]:

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

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

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].

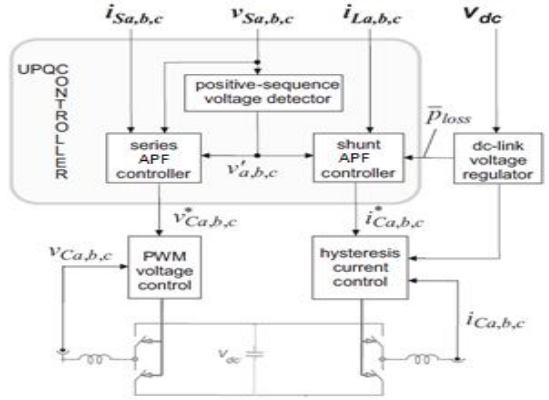

Fig. 2 Functional block diagram of a UPQC controller

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 Δe (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).

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

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

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

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 FLCS' PARAMETERS

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

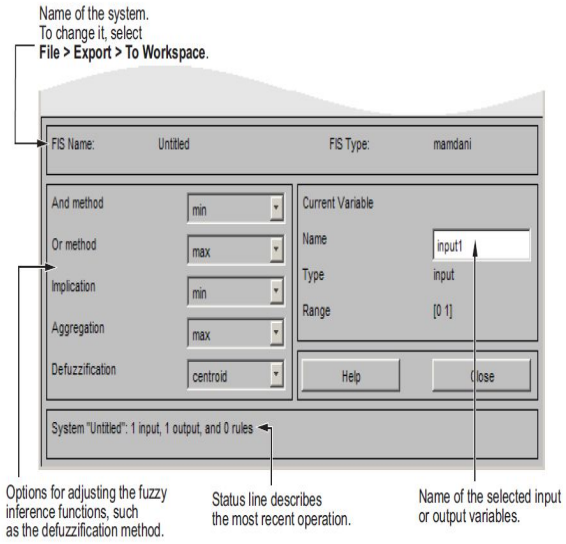

Fig. 3 FIS properties

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 = 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

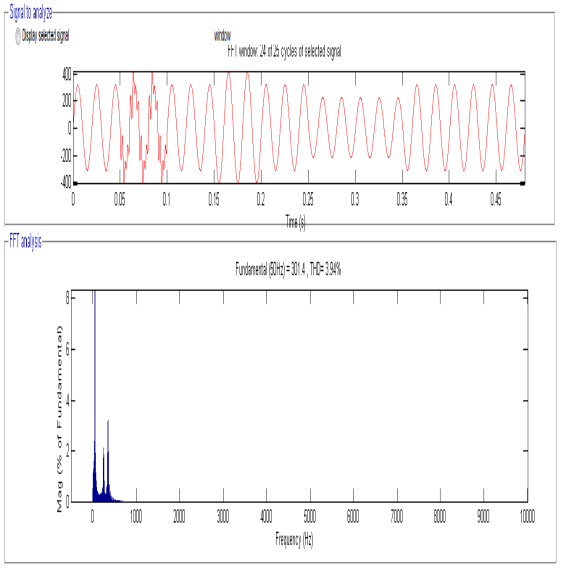

Fig. 4 Source voltage of the phase (a) and its specter

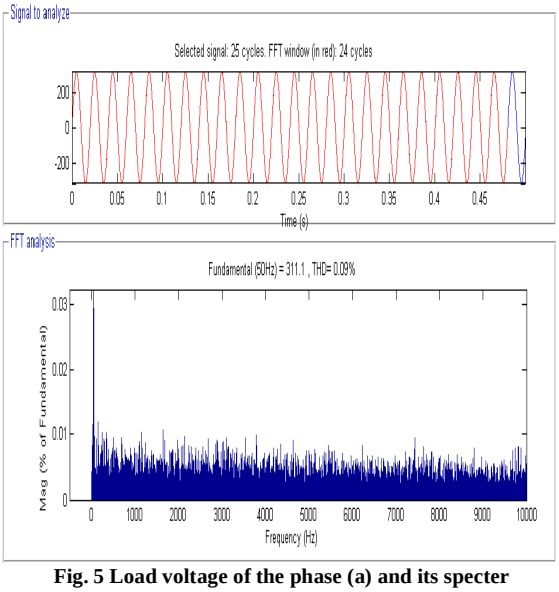

Fig. 5 Load voltage of the phase (a) and its specter

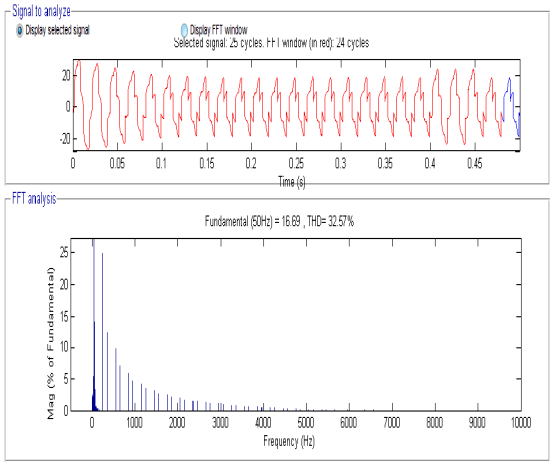

Fig. 6 Load current of the phase (a) and its specter

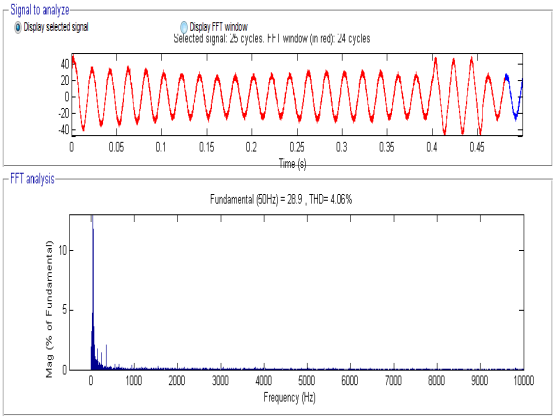

Fig. 7 Source current of the phase (a) and its specter

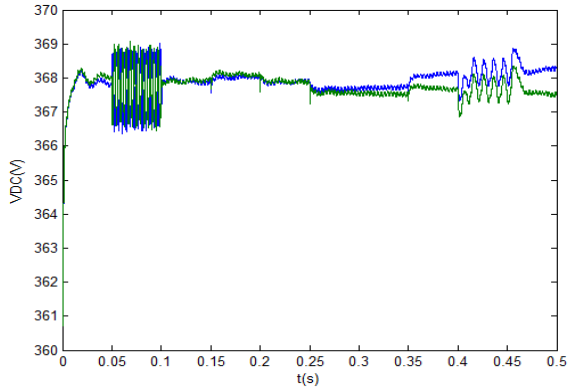

Fig. 8 DC voltage of UPQC

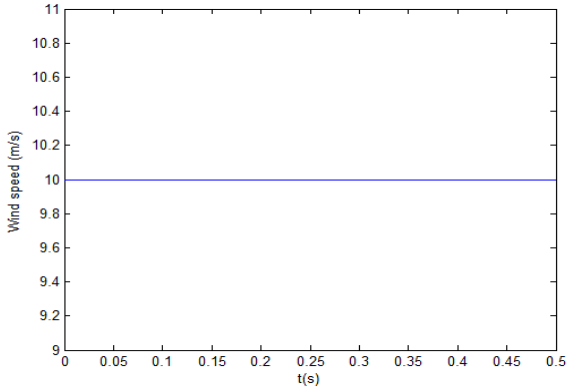

Fig. 9 Wind speed

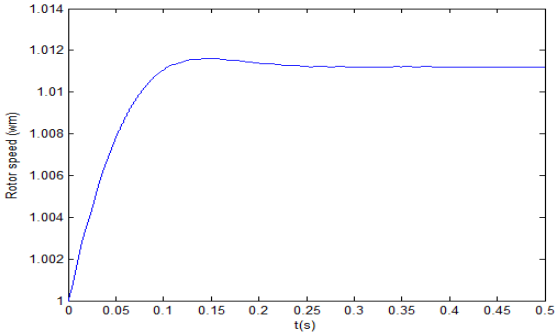

Fig. 9 Rotor speed

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 0.1to 1

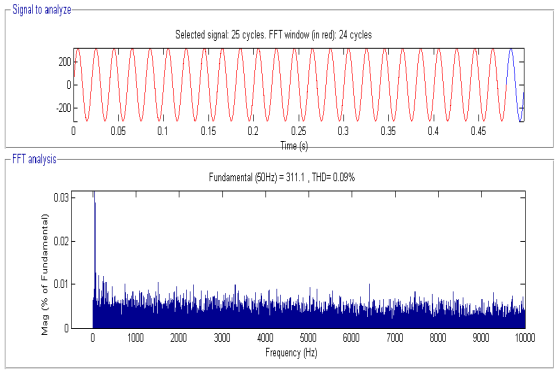

Fig. 11 Load voltage of the phase (a) and its specter

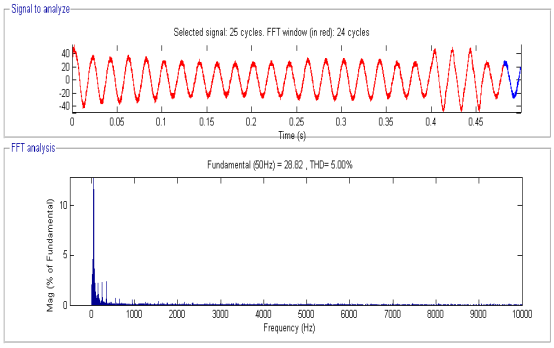

Fig. 12 Source current of the phase (a) and its specter

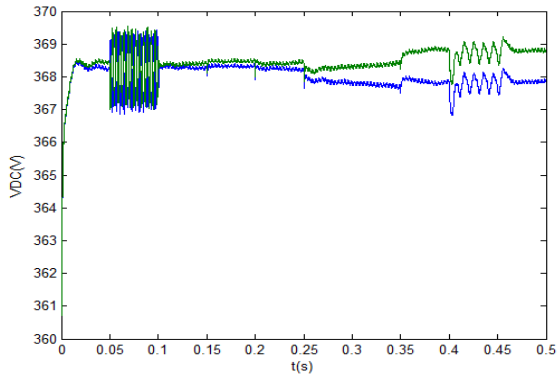

Fig. 13 DC voltage of UPQC

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

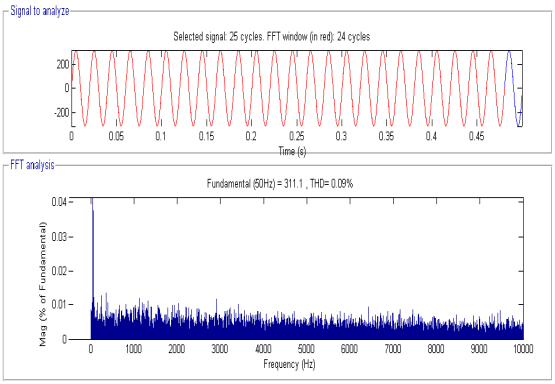

Fig. 13 Load voltage of the phase (a) and its specter

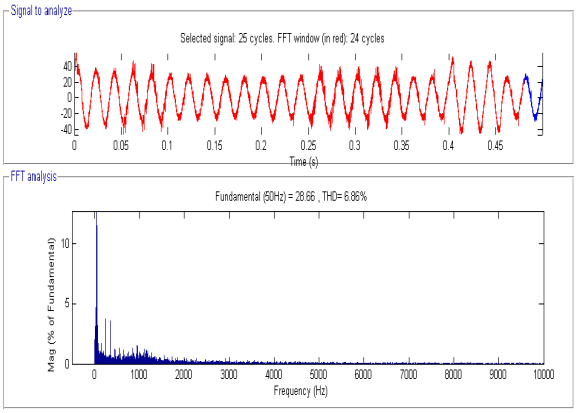

Fig. 15 Load voltage of the phase (a) and its specter

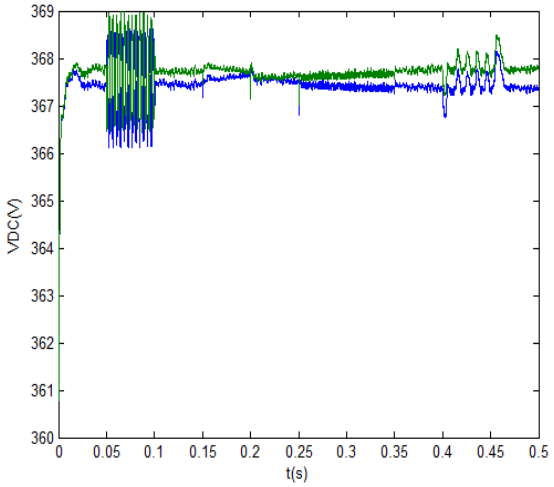

Fig. 16 DC voltage of UPQC

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.

REFERENCES

[1] M. Habab, C. Benachaiba, B. Mazari, H. Madi, and C. Benoudjafer, "Integration of UPQC Based on Fuzzy Controller for Power Quality Enhancement in Distributed Network," International Conference on Electrical, Computer, Electronics and communication Engineering (ICECECE 2014).

[2] Haidar, A.M.A., Benachaiba, C., Ibrahim, F. and Hawari, K., "Parameters Evaluation of Unified Power Quality Conditioner," IEEE International Conference on Electro/Information Technology (EIT), Mankato, MN, USA, 2011.

[3] Bruno W. França1, Leonardo F. da Silva1, Maurício Aredes1, Roberto Gerencer, David A. de C. Ferreira, Maria J. V. Siqueira, "Performance Analysis and Technical Feasibility of an iUPQC, Industrial Grids," Journal of Power and Energy Engineering, vol. 2, pp. 500-508, 2014.

[4] Okedu K. E., "A Study of Wind Farm Stabilization Using DFIG or STATCOM Considering Grid Requirements," jestr vol. 3, no. 1, pp. 200-209, 2010.

[5] Tomoki Asao, Rion Takahashi, Toshiaki Murata, Junji Tamura, and al, "Smoothing Control of Wind Power Generator Output

by Superconducting Magnetic Energy Storage System," Proceeding of International Conference on Electric Machines and Systems, Seoul, Korea, 2007.

[6] R. Takahashi, J. Tamura, M. Futami, M. Kimura and K. lde, "A New Control Method for Wind Energy Conversion System Using Double Fed Synchronous Generator," lEEJ Power and Energy, vol. 126, no. 2, pp. 225-235, 2006.

[7] Md Shafiuzzaman K. Khadem Mr, Malabika Basu, and Michael F. Conlon, "UPQC for Power Quality Improvement in DG Integrated Smart Grid Network – A Review," International Journal of Emerging Electric Power Systems, vol. 13, no. 1, 2012.

★★★

IMPACT OF PLANT HEIGHT AND IRRIGATION ON THERMAL PERFORMANCE OF EXTENSIVE GREEN ROOFS IN RIYADH CITY

[1]ASHRAF MUHARAM, [2]ELSAYED AMER, [3]NASSER AL-HEMIDDI

[1,2,3]king Saud university,king Saud university,king Saud university
E-mail: [1]ashraf.muharam@yahoo.com, [2]s_amereg@yahoo.com, [3]dr_n_hemiddi@yahoo.ca

Abstract- Increasing worldwide environmental concerns (Global warming, depletion of natural resources, acidrains, air and water pollutions, and ozone depletions) have led to the development of environmentally friendly construction practices. Green roof is one of the sustainable practices for reducing the environmental impact of a building. The study aim was identifying the impact of plant height and irrigation on thermal performance of an extensive green roof system in Riyadh city influenced by tropical and harsh climate.The experimental validations were applied on residential building in Riyadh city during the summer season in 2014. The experimental validations results indicated that the tall grass with average height from 6 to 15cm can reduce the temperature of internal air from 0.5 to 1°C, in comparison to the short grass with average height from 3 to 6 cm in similar conditions. While, the temperature of internal air differences were of 0.0±0.5°C with regular irrigation or irregular irrigation. However, when irrigation stopped more than two days, the grass would wither. Finally, this study has demonstrated that the grass height was more effective for its impact on the thermal performance than regular or irregular irrigation.

Keywords- Internal Temperatures,Irrigation,ShortGrass, Tall Grass, Thermal Performance.

I. INTRODUCTION

Green canopy have an important role for roof cooling, which is depending on plant species in terms of shading, evapotranspiration, and irrigation which acts as an insulator. The experimental results of [3]confirm that the plant canopy reflects 13% of incident global solar radiation and absorbs 56%, so that the solar radiation entering the system can be then estimated as 31% of the incident global solar radiation. The thermal behavior of a green roof is a complex phenomenon (such as shading, evapotranspiration, conductivity and absorption) and involves combined heat and mass transfer exchanges. Various studies have analyzed the thermal performance of green roofs in different plant varieties. According to [5]–[2], different plants have different results at the levels of effectiveness. As the amount of the coverage increased, the magnitude of the temperature changed (decreased). Because of this, the parametric variations in leaf area index (LAI) and foliage height thickness are carried out to determine the modulation of canopy air temperature, the reduction in the temperature width, and to estimate the penetrating heat flux. Also, foliage acts as a shading device under which convection provokes heat thermal exchange, but foliage absorbs part of the thermal energy because of its vital process of photosynthesis.
Furthermore, the results being drawn from the study of [8]showed that the effects of temperature reduction decrease with plant height. The best reductions in temperature occurred in 35 cm plants, followed by 15 cm and then 10 cm plants. The results also indicate that plants with green colored leaves are more effective than purple/red leafed plants in rooftop heat insulation. The leaf surface temperatures in this study were measured with infrared thermal imagers. However, the study of [15] found out that the most important parameter, when considering vegetation, is the foliage density. The foliage height alone is not one of the crucial factors affecting the performance of this cooling technique, but only in combination with the density of the vegetation layer. Moreover, the study of [1]found out that a larger leaf area index(LAI) reduces the solar flux penetration, stabilizes the fluctuating values, and reduces the indoor air temperature. Also, the study showed notably that in terms of evapotranspiration (ET) and solar heat gains factor (SHF), the foliage density and hence the vegetable canopy type selection influence the thermal efficiency of the climatic insulation greatly. In addition, the study of [10]compared the thermal effectiveness among three kinds of plant (Sedum, Plectranthus, and Kalanchoe) on an extensive green roof in an Indian Ocean area under a tropical humid climate. The results showed that Sedum green roof led to a higher heat restitution rate with 63%, than for Plectranthus (54%), and Kalanchoe (51%). In general, the results drawn from the study of [11] showed that a green roof which has high vegetation density acts as a passive cooling system. The incoming thermal gain is about 60% lower than when the roof has no vegetation. Irrigation is required to sustain vegetation throughout the extended dry periods. The water requirements of the plant species is from 2.6 to 9.0 L/m2per day, depending on the plant kind and the surrounding conditions [14]. Moreover, the study of [7]compared the irrigation among four plant types (C. chinense, C. variegatum, S. trifasciata, and cv. Laurentii). The study indicated that if plant leaves have greater evapotranspiration rates, they would not adapt to arid and severe environments for longer periods, thereby increasing water consumption. In contrary, plants with low evapotranspiration rates are suitable for arid and severe environments, thereby saving water resources. In addition, the study of [13]provided experimental evidence for a positive effect of the water retention

layer on water status and drought survival of plants growing over green roofs. The water retention layer is better than the natural sand and soil for increasing the amount of water available in green roof systems. Therefore, some studies investigated the irrigation impact on the thermal performance of the extensive green roofs. According to [12]–[2]the presence and the quantity of water largely influence the thermal properties of green roofs. In fact, a wet roof provides additional evapotranspiration, which prevents the heat flux in buildings and acts as a passive cooler by removing heat from buildings. Also, the study of [4]found out that the difference between the soil surface temperature of a dry substrate and a saturated substrate is about 25 °C. In conclusion, the study of [9]found out that supplemental irrigation is required for maintaining plant diversity on an extensive green roof, but not necessarily plant cover or biomass which depends on the growing media type being used. Also, the results showed that planting extensive green roofs with a mix of plant species can ensure the survival of some species; maintaining cover and biomass when supplemental irrigation is turned off to conserve water, or during extreme drought.

II. METHODOLOGY

The method being adopted in this research depends on the mixed scanning approach which involves reviewing the research problem in the literature and compare the theoretical findings with the experimental validations in order to identify the impact of plant height and irrigation on the thermal performance of the extensive green roof in Riyadh city.

2.1 Application study

In order to obtain an experimental data regarding the thermal behavior of extensive green roofs and their interactions with the energy performance of buildings, an experimental platform with green roofs system was constructed in the Deraib region which is located in the north of Riyadh city. The experimental platform is a simple repetition of residential rooms being built by similar materials. The platform consists of two rooms which are used for the study of treatment of the energy efficiency of buildings by using a selective standard for extensive green roof properties, and conventional roofs (concrete roof with depth of 15cm), see Figure (1). Also, the facades of these rooms will be painted with the Paige color, see Figure (2). To reflect a real urban setting, the experiment was conducted on the residential building that could simulate both physical and geometrical similarities in reality. The application study consists of three stages: the stage of experiment preparation, the stage of data collection, and the stage of data analysis and discussion.

2.2 Heat measurement equipment

The normality of temperature and the relative humidity data was checked by using (The EL-USB-2-LCD+) which measured the air temperature and the relative humidity inside the rooms and outside the rooms every five minutes. Thermocouples sensors (ANRITSU Digital handheld thermometer - ANRITSU MTER CO.,LTD) were arranged in different levels within the model to include the components of the empirical model so as to measure the covariance of temperature. Heat flux sensors were placed on the surface of the plants, walls, and at the ceiling layer in order to assess the amount of the heat conduction of those components. The results of the experiment were analyzed by using the statistical analysis program of Microsoft Excel.

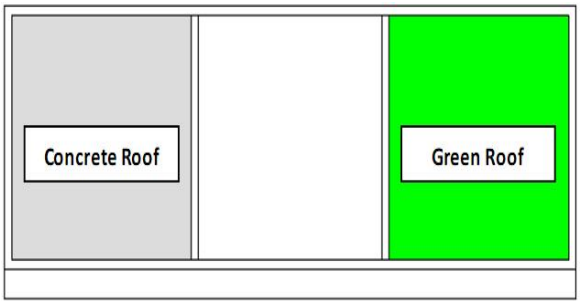

Figure: (1) The Plan's view of the experimental program.



Figure: (2) shows the exterior finishes in test rooms.

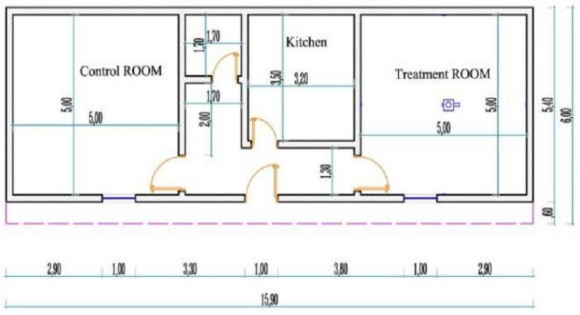

Figure: (3) A Plan's view of the rooms being tested.

A Pre-cultivated system (Vegetative Blanket - Tifway 419 Bermuda) was used in this experiment. This type typically comes in rolled that can be placed on any roof and be grown off-site. Also, this type has a good advantage ; namely, it is very thin (very lightweight option) compared to the other types.

An extensive green roof system consists of following matter Figure (4):

- A5 mm thick styrene butadiene rubber (SBR) waterproofing membrane (preventing water from

reaching the roof decking in an actual field installation).

- A 0.1 mm thick polyethylene slip sheet allowed any moisture in the waterproofing membrane to exit the system and saving water for irrigation.
- A 3 cm thick gravels which is as drainage layer and saving soil from erosion.
- A 2 cm thick sand that acts as a filter layer for drainage.
- A 4 cm thick soil which consists of mixed ratio (1:1:3) –(batamos: clay soil: soft sand) with organic materials.
- A 3 cm thick vegetative roll layer with Cynodondactylon (Bermuda- Tifway - 419) grass.

Drainage pipes of excess water from the growing medium were channeled and installed in the corners of the green roof substrate to allow water to drain freely from the system.

2.3 Installation of Measuring devices

There are 24 sensors that are used in this test. Eight sensors are in the green roof system, see Figure (5), two sensors are in the concrete roof system, six sensors are in the treatment room walls, six sensors control room and two sensor out test rooms.

III. DATA COLLECTION AND ANALYSIS

Thermal performance of extensive green roofs was during the warm period. The warm period chosen for the analysis was in June 2014 from (06-June to 23-June), which is a representative of a typical summer season in Riyadh city. The daytime is characterized by high loads of solar radiation with an average air temperature of 42◦C and an average relative humidity of 15.1%. Days presented winds with daily average and max value from 4.0 km/h to17.0 km/h.

3.1 Grass Height

A Tall Grass

Figure (6) shows the high of grass during the time period test. The height was from 8cm to 15cm. Figure (7) shows that the average values of the internal air temperature differences were of 5.5±2°C among the treatment and control rooms with tall grass, when the external air temperature reached to 44°C.

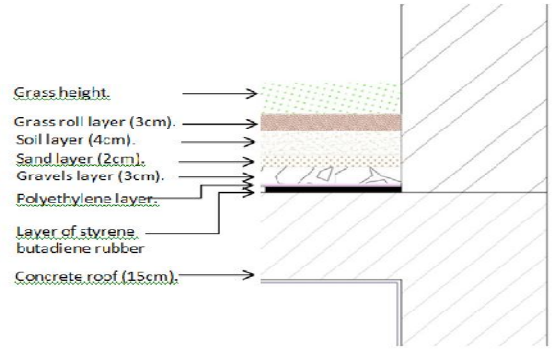

Figure: (4) The vertical section shows the various components of the extensive green roofing system

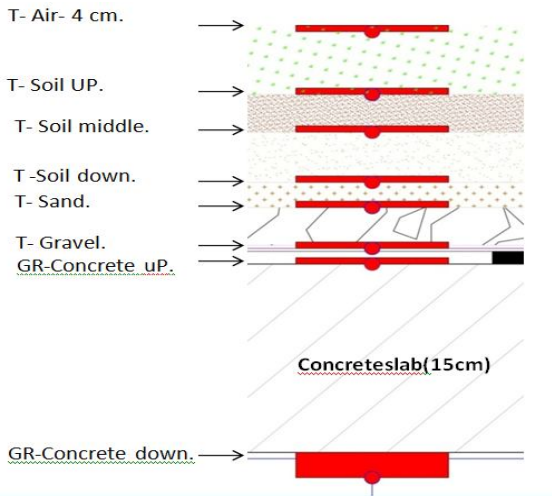

Figure: (5) The vertical section shows the sensors' places in the extensive green roof system.



Figure: (6) Shows the growth of the tall grass of (8-15) cm during the testing period.

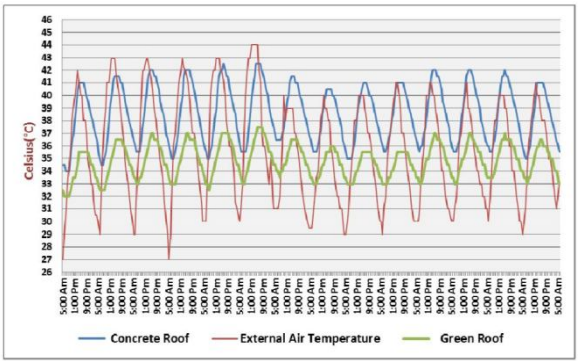

Figure: (7) Temperature variation of the internal air temperature in treatment room and control room with tall grass during the time period from 6-6-2014 at 5:Am to 20-6-2014 at 5:Am.

Figure (8) shows the temperature of thermocouples in substrate layer of extensive green roof system. The average values of substrate layers temperature differences were of 1±.01°C during the testing time period. The maximum temperature of substrate layers reached to 50°C when the external air temperature was 43°C and the minimum temperature of substrate layers reached to 34°C when the external air temperature was 28°C. However, the internal ceiling temperature was lower than the top layer of substrate (grass layer) up from 4°C to 14°C. While the air temperature at 4cm in

the grass layer reached 58°C because of the evapotranspiration phenomenon. Also, Figure (8) shows that the performance of substrate layers were different during the time period of day. During the night period, the lower layers of temperature were lower than the uppers layers of temperature. While during daylight period, the lower layers of temperature were higher than the uppers layers of temperature.

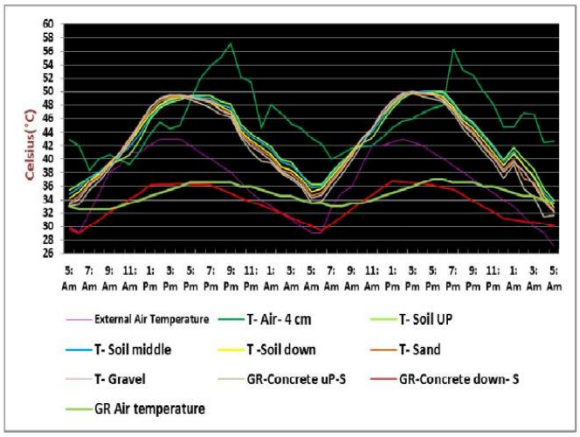

Figure: (8) Temperature variation of substrate layers with tall grass (regular irrigation) during the time period from 7-6-2014 at 5: Am to 9-6-2014 at 5:Am.

B Short Grass

Figures (9 and 10) show the method of cutting grass to test the impact of grass height on the thermal performance of the extensive green roof system. The grass height after cutting was from 3cm to 5cm.



Figure: (9) Shows the method of cutting grass.



Figure: (10) Shows short grass on 20-6-2014.

Figure (11) shows that the average values of the internal air temperature differences were of 5.5±2.5°C for the extensive green roof system (with short grass) being compared to the concrete roof system, when the maximum external air temperature reached 42°C and the minimum external air temperature reached 29°C. Also, Figure (12) shows the temperature of thermocouples in the substrate layer of the extensive green roof system after cutting grass with 5cm height. The average values layers temperature differences were of 2.5±.01°C during the daylight. The maximum temperature of substrate layers reached to 51°C when the temperature of external air was 41°C. However, the temperature of internal ceiling was lower than the top layer of the substrate (grass layer) from 7°C to 13°C during the daylight.

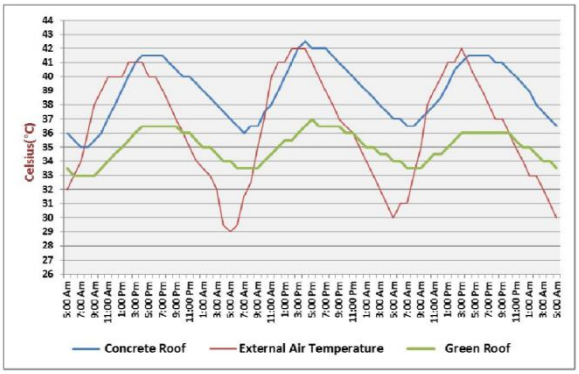

Figure: (11) Temperature variation of the internal air temperature in test rooms with short grassduring the time period from 20-6-2014 at 5:Am to 23-6-2014 at 5:Am.

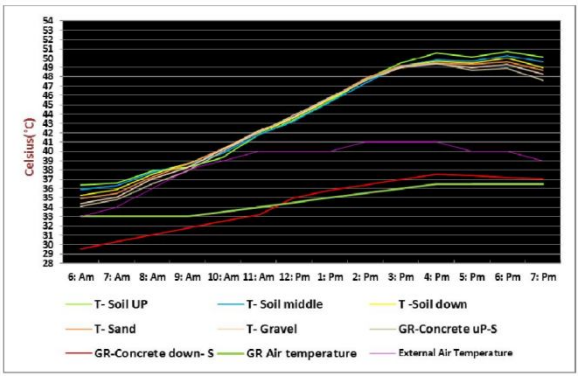

Figure: (12) Temperature variation of substrate layers with short grass (regular irrigation) during the time period from 20-6-2014 at 6:Am to 20-6-2014 at 7:Pm.

3.2 Irrigation

Irrigation was required to sustain vegetation throughout the extended dry periods. The water requirements of the plant species in this experiment were 6.0 L/m2 per day. The manual irrigation method was used at 6:30 pm every day for five to six minutes, see Figure (13).



Figure: (13) The method of manual irrigation during the testing period.

A The impact of irrigation on the temperature of internal air As shown in Figure (14), the temperature of internal air in the treatment room (with regular irrigation) was lower than the temperature of internal air in the same room (without irrigation for one day to two days). The differences were of 0.5°C during the

testing period. This means that the higher the water volumetric content, the lower the minimum of the daily temperature.

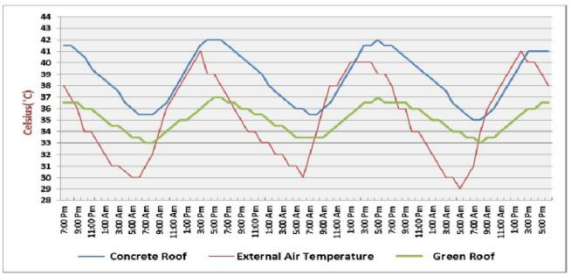

Figure: (14) Temperature variation of the internal air temperature in treatment room and control room with tall grass (first day irrigation, next day off and third day off too) during the time period from 160-6-2014 at 7:Pm to 19-6-2014 at 5:Pm.

B The impact of irrigation on the performance of substrate layers

Figure (15) shows the impact of regular and irregular irrigation on the temperature of substrate layers in the extensive green roof system with tall grass through the thermocouples sensors. When the temperature of external air was 40°C, the average values layers of the temperature differences were of 2.5±.5°C during the daytime. When regular irrigation, the maximum temperature of substrate layers reached 49°C, while with irregular irrigation (day off) the maximum temperature of substrate layers reached 51.4°C .

In addition, While the air temperature at 4cm in the grass layer reached 57.8°C on the day of regular irrigation. It reached 49.5°C on the day with irregular irrigation (day off) because of the evapotranspiration phenomenon. Before the irrigation, the soil temperature of the layer surface reached 49°C, while the water was cold. So, the water evaporated and the air temperature increased.

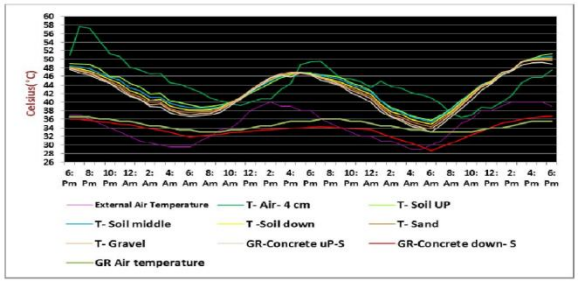

Figure: (15) Temperature variation of substrate layers temperature in extensive green roof system with tall grass (first day irrigation and the second day off) during the time period from 12-6-2014 at 6: Pm to 14-6-2014 at 6:Pm.

IV. DISCUSSIONS

The discussion focused on the impact of substrate components (grass height and water content) and the temperature of internal walls on the thermal performance of the extensive green roof system. The discussion includes the temperature variation of the internal air, Substrate layers, and internal (Globe) temperature.

4.1 Grass Height

The tall grass with average height from 6 to 15cm can reduce the temperature of internal air from 0.5 to 1°C, in comparison to the short grass with average height from 3 to 6 cm in similar conditions, as it is shown in Table (1). In the treatment room with tall grass, the temperature of internal airvaried from 35.5 to 33°C. But in the treatment room with short grass, the temperature of internal air varied from 36.5 to 33.5°C. This means that the leaf area and the foliage height thickness could reduce penetrating heat flux by shading and evapotranspiration phenomenon.

Moreover, the grass height has a significant impact on the temperature of the substrate layer. As shown in Table (2), the temperature of substrate layers varied from 50 to 32°C with tall grass, while the temperature of substrate layers varied from 51 to 33°C the maximum temperature of the external air were 43°C and 41°C respectively during the daylight. So, the tall grass temperature of substrate layers was lower than that of the short grass during similar conditions. However, the temperature of beneath layer in the substrate (Gravels layer) was lower than the top layer in the substrate (soil layer) during the first morning hours. But at noon, the gravel layer temperature was higher than the soil layer, due to the increasing of the thermal storage.

Celsius	Internal Air Temperature			
	Time period from 15-6-2014 at 5: Am to 16-6-2014 at 5:Am.		Time period from 20-6-2014 at 5: Am to 21-6-2014 at 5:Am.	
	External Air Temperature	Treatment Room (Green Roof) Tall Grass	ExternalAir Temperature	Treatment Room (Green Roof) Short Grass
Maximum	41°C	35.5°C	41°C	36.5 °C
Minimum	29°C	33°C	30°C	33.5°C
Difference	12°C	2.5°C	11°C	3°C

Table: (1) Temperature variation of the internal air temperature in treatment room with tall grass and with short grass.

Celsius	Substrate layers Temperature Variation			
	Time period from 7-6-2014 at 6: Am to 7-6-2014 at 7: Pm.		Time period from 20-6-2014 at 6: Am to 20-6-2014 at 7: Pm.	
	External Air Temperature	Treatment Room (Green Roof) Tall Grass	ExternalAir Temperature	Treatment Room (Green Roof) Short Grass
Maximum	43°C	50°C	41 °C	51 °C
Minimum	30°C	32°C	33°C	33°C
Difference	13°C	18°C	8°C	18°C

Table: (2) Temperature variation of substrate layers temperature with tall grass and with short grass.

4.2 Irrigation

As shown in Table (3), the regular irrigation or irregular irrigation in the extensive green roof system did not have a significant impact on the thermal behavior of the extensive green roof system. The temperature of internal air in the treatment room with regular irrigation varied from 36.5 to 33.5°C during the daylight, while it varied from 37 to 33.5°C in the treatment room with irregular irrigation when the external air temperature varied from 40 to 31°C and from 40 to 30°C, respectively. The temperature of internal air with regular irrigation was lower than that with irregular irrigation. The temperature differences were of 0.0±0.5°C. However, when irrigation stopped more than two days, the grass would wither. In addition, as shown in Table (4), the temperature of substrate layers varied from 49 to 33.6°C with regular irrigation, while the temperature of substrate layers with irregular irrigation varied from 51.4 to 33°C when the external air temperature varied from 40 to 30°C during the daylight. The substrate layers temperature differences were of 2.4±0.6°C with regular or irregular irrigation. From these results and through the comparison of the impact of grass height and irrigation on the thermal performance of extensive green roof, the grass height was more effective for its impact on the thermal performance than regular or irregular irrigation.

Celsius	Internal Air Temperature			
	Time period from 12-6-2014 at 5: Am to 12-6-2014 at 5: Pm.		Time period from 18-6-2014 at 5: Am to 18-6-2014 at 5: Pm.	
	External Air Temperature	Treatment Room (Green Roof) regular irrigation	ExternalAir Temperature	Treatment Room (Green Roof) Irregular irrigation
Maximum	40°C	36.5°C	40°C	37°C
Minimum	31°C	33.5°C	30°C	33.5°C
Difference	9°C	3°C	10°C	2.5°C

Table: (3) Temperature variation of substrate layers temperature with regular and irregular irrigation.

Celsius	Substrate layers Temperature Variation			
	Time period from 13-6-2014 at 5: Am to 13-6-2014 at 7: Pm.		Time period from 14-6-2014 at 5: Am to 14-6-2014 at 7: Pm.	
	External Air Temperature	Treatment Room (Green Roof) regular irrigation	ExternalAir Temperature	Treatment Room (Green Roof) Irregular irrigation
Maximum	40°C	49°C	40°C	51.4°C
Minimum	29°C	33.6°C	29°C	33°C
Difference	11°C	16°C	11°C	18°C

Table: (4) Temperature variation of the internal air temperature in treatment room with regular and irregular irrigation.

CONCLUSION

A number of conclusions can be drawn from the experimental study presented and
discussed in this study. The conclusions are the main results of this study.

The results of this study indicate that:

- Tall grass (6 to 15) cm was better than short grass (3 to 5) cm for reducing the temperature of internal air from 0.5 to 1°C.
- Tall grass (6 to 15) cm has a significant impact on the temperature of the substrate layer during the daylight in comparison with short grass (3 to 5). The temperature variation reached 3.8°C.
- The regular irrigation or irregular irrigation in the extensive green roof system did not have a significant impact on the thermal behavior of the extensive green roof system, especially for internal air temperature. The maximum temperature variation was up to 0.5°C. However, when irrigation stopped more than two days, the grass would wither.
- Water content with regular irrigation could cool the temperature of substrate layers more than irregular irrigation. The substrate layers temperature differences were of 2.4±0.6°C with regular or irregular irrigation.
- The temperature of internal walls in the treatment room (Green Roof) was higher than that in the control room (Concrete Room). However, the temperature of internal air in the treatment room was lower than that in the control room due to the use of the extensive green roof system. The temperature differences of internal air were of 5.5±2°C.
- Due to the increase of the thermal storage, the temperature of the beneath layer in the substrate (Gravels layer) was lower than the top layer in the substrate (soil layer) during the first morning hours, while at noon the gravel layer temperature was higher than the soil layer.

ACKNOWLEDGMENTS

This project was supported by the Research Center of Architecture and Planning College, King Saud university, Kingdom of Saudi Arabia.

REFERENCES

[1] Abalo, S., Banna, M. and Zeghmati, B. “Performance analysis of a planted roof as a passive cooling technique in hot-humid tropics,” Renewable Energy Journal, Vol. 39,pp.140–148, 2012.

[2] Berardi, U., Hoseini, A.M.G. and, Hoseini, A.G.“State-of-the-art analysis of the environmental benefits of green roofs,”Applied Energy Journal, Vol. 115,pp.411–428, 2014.

[3] D’Orazio, M., Di Perna, C. and Giuseppe, E.D. “Green roof yearly performance: A case study in a highly insulated building under temperate climate,”Energy and Buildings Journal, Vol. 55,pp.439–451, 2012.

[4] Djedjig, R., Ouldboukhitine, S., Belarbi, R. and Bozonnet, E.“Development and validation of a coupled heat and mass

transfer model for green roofs," International Communications in Heat and Mass Transfer, Vol. 39,pp.752–761, 2012.

[5] Kumar, R. and Kaushik, S. "Performance evaluation of green roof and shading for thermal protection of buildings," Building and Environment Journal, Vol. 40,pp.1505- 1511 , 2005.

[6] Lin, B., Yu, C., Su, A. and Lin, Y. "Impact of climatic conditions on the thermal effectiveness of an extensive green roof," Building and Environment Journal, Vol. 67,pp.26–33, 2013.

[7] Lin, Y. and Lin, H. "Thermal performance of different planting substrates and irrigation frequencies in extensive tropical rooftop greeneries," Building and Environment Journal, Vol. 46,pp.345–355, 2011.

[8] Liua, T.C., Shyu, G.S., Fang, W.T., Liu, S.Y. and Cheng, B.Y."Drought tolerance and thermal effect measurements for plants suitable for extensive green roof planting in humid subtropical climates,"Energy and Buildings Journal, Vol. 47,pp.180–188,2012.

[9] MacIvor, J.S., Margolis, L., Puncher, C.L. and Matthews, B.J.C. "Decoupling factors affecting plant diversity and cover on extensive green roofs,"Journal of Environmental Management, Vol. 130,pp.297–305, 2013.

[10] Morau, D., Libelle, T. and Garde, L. "Performance Evaluation of Green Roof for Thermal Protection of Buildings In Reunion Island," Energy Procedia Journal, Vol. 14,pp.1008–1016, 2012.

[11] Olivieri, F., Perna, C.D., D'Orazio, M., Olivieri, L. and Neila, J. " Experimental measurements and numerical model for the summer performance assessment of extensive green roofs in a Mediterranean coastal climate," Energy and Buildings Journal, Vol. 63,pp.1–14, 2013.

[12] Santamouris, M. "Cooling the cities – A review of reflective and green roof mitigation technologies to fight heat island and improve comfort in urban environments,"Solar Energy journal, 2012.

[13] Savi, T., Andri, S. and Nardini, A."Impact of different green roof layering on plant water status and drought survival,"Ecological Engineering Journal, Vol. 57,pp.188–196, 2013.

[14] Schweitzer, O. and Erell, E. "Evaluation of the energy performance and irrigation requirements of extensive green roofs in a water-scarce Mediterranean climate," Energy and Buildings Journal, Vol. 68,pp.25- 32, 2014.

[15] Theodosiou, T.G. "Summer period analysis of the performance of a planted roof as a passive cooling technique," Energy and Buildings Journal, Vol. 35,pp.909–917, 2003.

★★★

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

BEHROOZ NOORI

[1]Department of Industrial Engineering West Tehran Branch, Islamic Azad University Tehran, Iran
E-mail: [1]b.noori@wtiau.ac.ir, [2]bnoori@gmail.com

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). Mobilebanking, 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 ofliterature by data mining in mobile banking services(Sangle & Awasthi, 2011).

In relation to customer-centric business intelligence, banks are usually concerned with the following commonMarketing 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 businessmetrics about customers' profitability andvalues, for instance, the recency, frequencyand monetary (RFM) model, and thecustomer life value model(D. Chen et al., 2012).

In this article a case study of using datamining techniques in customer-centricbusiness intelligence for a bankwas presented. The main purpose of this analysis is to helpthe bank better understand its mobile banking customersand therefore conduct customer-centricmarketing more effectively. On the basisof anewsegmentation model, customers of the bank have been segmented into variousmeaningful groups. Accordingly, a set ofrecommendations was provided to thebank 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).

Particularlyin Iran, banking services on mobile banking were launched few years ago yet the usage of such services has not reached thedesired 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-sellingAnalysis

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" isnot only to "increase the customer's reliance on the company and decrease thelikelihood of switching to another provider" but also to exert a generally positiveinfluence on the relationship with the customer, strengthening the link betweenprovider and user (Kamakura, Wedel, De Rosa, & Mazzon, 2003). Increasing product holding leads to anincreased number of connection points with customers, as well as increasing theswitching 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 toknow it customers better through a greater understanding of buying patterns andpreferences. This, in turn, puts it in a better position to develop offerings that meetcustomer needs.

Consequently, it is argued that cross-sellingincreases 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 inboth research and management in the financial services industry. Denoting to termssuch as "bancassurance" and "allfinanz", i.e. the sales of insurance products by banks, and on the other hand "assurfinance", i.e. the salesof financial products by insurance companies, changes in the market such as deregulation and increasingcompetition have driven the once traditional financial service providers towardsincreasing provision of integrated financial services, that is, offering their customers aseamless 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 operationalizingthe 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, stable, substantial, and actionable(Edris, 1997).

2.4. CLV and RFM Analysis

Customer segmentation is used in differentsettings, for instance, using customer segmentationfor estimating customer future valueas a part of customer lifetime value (CLV) in banking scope (Khobzi, Akhondzadeh-Noughabi, & Minaei-Bidgoli, 2014). Generally, customersegmentation is often used to obtain moredetails about different customers in bankingscope. Actually, according to these studiesdiverse groups of banks' customers are identified by segmenting based on customers' financial transactions(Khobzi et al., 2014).

RFM analysis is a widely used method thatidentifies customer behavior and representscustomer behavior characteristics, and it standsfor the words: Recency, Frequency, and Monetary.Generally, these parameters are defined asfollows(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 varyin different cases. In recent years, several researcherstried to extend the concept of RFManalysis, 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.

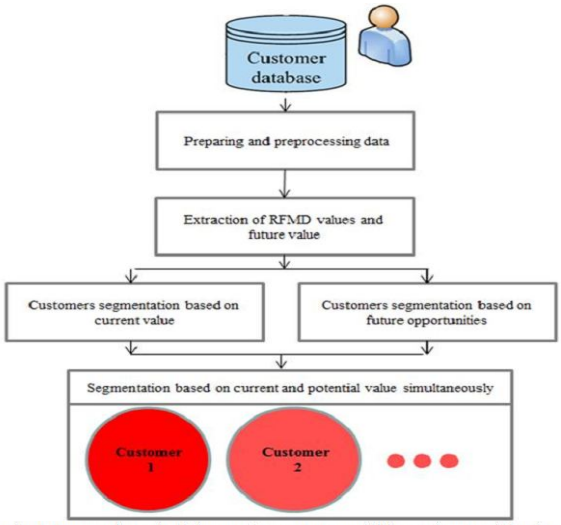

Fig. 1. Research methodology using RFMD variables and potential value.

Moreover, the rapid development of data mining methodsenables using large data bases of customer data toextract the knowledge, supporting marketing decisionprocess. Asthe ability to acquire new customers and retain existing iscrucial, especially in the finance marketplace, thepossibility of customer segmentation by obtaining theinformation on unknown hidden patterns has a majorsignificance. Until now only few papers present usingof data mining techniques in banks. In ourwork, we consider application of a new RFM segmentation algorithmin 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 utilizeda 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 × F × M×D

The rationale ofthe proposed approach is that if customers have hadsimilar purchasing behavior, then theyare very likely also to have similar RFMD values. RFMD values were used tocluster 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	-

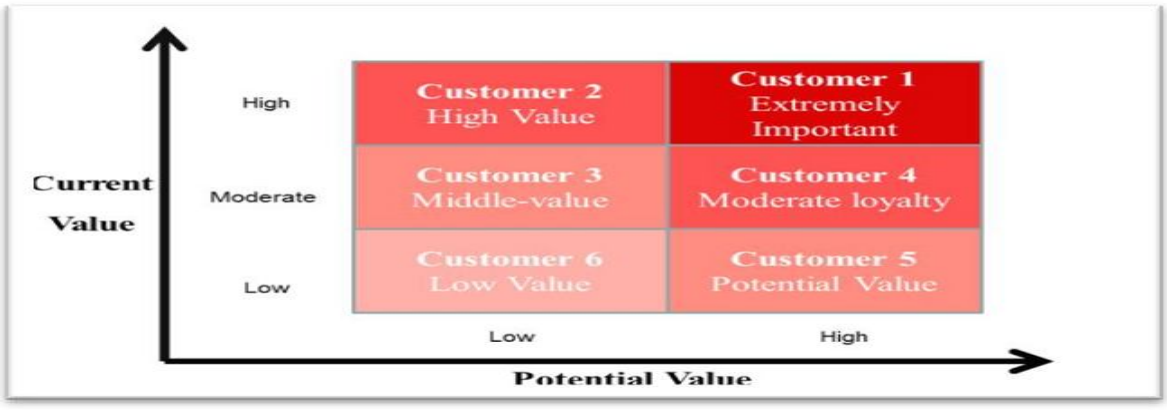

Fig. 2. Customer segmentation result based on CLV

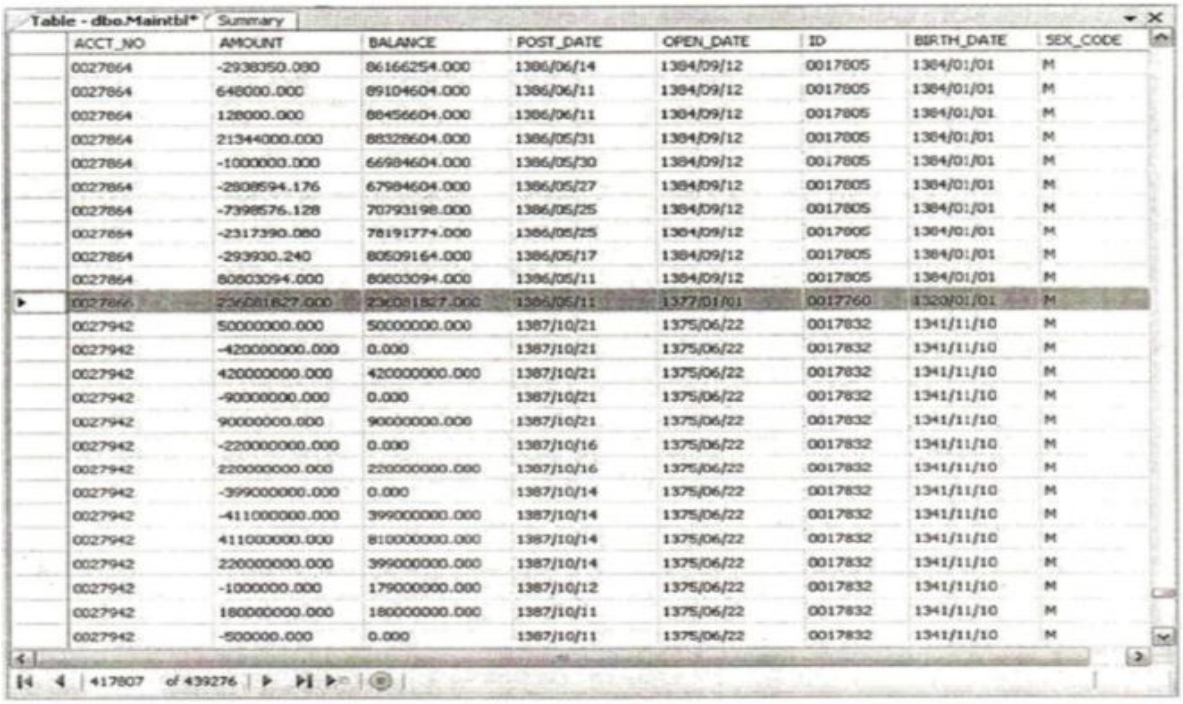

Table - dbo.Maintbl* | Summary

ACCT_NO	AMOUNT	BALANCE	POST_DATE	OPEN_DATE	ID	BIRTH_DATE	SEX_CODE
0027864	-2938350.080	86166254.000	1386/06/14	1384/09/12	0017805	1384/01/01	M
0027864	648000.000	89104604.000	1386/06/11	1384/09/12	0017805	1384/01/01	M
0027864	128000.000	88456604.000	1386/06/11	1384/09/12	0017805	1384/01/01	M
0027864	21344000.000	88328604.000	1386/05/31	1384/09/12	0017805	1384/01/01	M
0027864	-1000000.000	66984604.000	1386/05/30	1384/09/12	0017805	1384/01/01	M
0027864	-2808594.176	67984604.000	1386/05/27	1384/09/12	0017805	1384/01/01	M
0027864	-7398576.128	70793198.000	1386/05/25	1384/09/12	0017805	1384/01/01	M
0027864	-2317390.080	78191774.000	1386/05/25	1384/09/12	0017805	1384/01/01	M
0027864	-293930.240	80509164.000	1386/05/17	1384/09/12	0017805	1384/01/01	M
0027864	80803094.000	80803094.000	1386/05/11	1384/09/12	0017805	1384/01/01	M
0027866	236081827.000	236081827.000	1386/05/11	1377/01/01	0017760	1320/01/01	M
0027942	50000000.000	50000000.000	1387/10/21	1375/06/22	0017832	1341/11/10	M
0027942	-420000000.000	0.000	1387/10/21	1375/06/22	0017832	1341/11/10	M
0027942	420000000.000	420000000.000	1387/10/21	1375/06/22	0017832	1341/11/10	M
0027942	-90000000.000	0.000	1387/10/21	1375/06/22	0017832	1341/11/10	M
0027942	90000000.000	90000000.000	1387/10/21	1375/06/22	0017832	1341/11/10	M
0027942	-220000000.000	0.000	1387/10/16	1375/06/22	0017832	1341/11/10	M
0027942	220000000.000	220000000.000	1387/10/16	1375/06/22	0017832	1341/11/10	M
0027942	-399000000.000	0.000	1387/10/14	1375/06/22	0017832	1341/11/10	M
0027942	-411000000.000	399000000.000	1387/10/14	1375/06/22	0017832	1341/11/10	M
0027942	411000000.000	810000000.000	1387/10/14	1375/06/22	0017832	1341/11/10	M
0027942	220000000.000	399000000.000	1387/10/14	1375/06/22	0017832	1341/11/10	M
0027942	-1000000.000	179000000.000	1387/10/12	1375/06/22	0017832	1341/11/10	M
0027942	180000000.000	180000000.000	1387/10/11	1375/06/22	0017832	1341/11/10	M
0027942	-500000.000	0.000	1387/10/11	1375/06/22	0017832	1341/11/10	M

417807 of 439276

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 opportunitiesshould 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 workconsidered a bankcustomer 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 segmentationsystem a bank would not be able to perform valid and reliable customerprospecting which in turn would seriously undermine the effectiveness andprofitability of customer targeting. The starting point for serious customerprospecting 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 rudimentarysocio-demographic data such as the customer's age, sex, maritalstatus and some employment information. Customer prospecting and targetingcould be undertaken employing such data. Customers would be placed in groups. Many organizations have realized that byenhancing their customer database they can significantly improve their customer prospecting and increase the lift ofcustomer targeting strategies. Thus, segmentation is designed to exploit thepotential of the bank's customer database. Once a specific customer segmentgenerated by RFMDsegmentation has been identified, it becomes relativelysimple to identify the customer prospects and target them with the appropriatestrategy and promotional tools(Zuccaro & Savard, 2010).
- Develop effective communications. In the age of segmentation, developingan effective communication strategy is not a simple task. The nature and varietyof potential communication messages and media to transmit the messages hasgrown exponentially during the last two decades. In addition, mostorganizations, including banks, are abandoning traditional communicationmedia such as television and radio and opting for more specialized vehicles suchas the web. Segmentation provides the bank with a richer set of segments that can be described with animpressive level of detail. The refined segments along with detailed financial life style of its membersallow 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 notonly required to be aware of the needs of theircustomers, but they should be able to satisfyeffectively the needs of each identified customersegment. This study provides evidencethat segmentation of the customers is of great importance to banks inorder to identify the behavior of each segmentand provide certain marketing actions that best suitthese behaviors.The results of this study provide a practicalapproach to Iranian banks that

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

Furtheremore, 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 introducednew RFM model toimprove 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 managersto managemobile users' behavior.

REFERENCES

[1]. Ansell, J., Harrison, T., & Archibald, T. (2007). Identifying cross-selling opportunities, using lifestyle segmentation and survival analysis. Marketing Intelligence & Planning, 25(4), 394-410.

[2]. Bizhani, M., & Tarokh, M. (2011). Behavioral rules of bank's point-of-sale for segments description and scoring prediction. International Journal of Industrial Engineering Computations, 2(2), 337-350.

[3]. Chen, C.S. (2013). Perceived risk, usage frequency of mobile banking services. Managing Service Quality, 23(5), 410-436.

[4]. Chen, D., Sain, S.L., & Guo, K. (2012). Data mining for the online retail industry: A case study of RFM model-based customer segmentation using data mining. Journal of Database Marketing & Customer Strategy Management, 19(3), 197-208.

[5]. Edris, T. (1997). Services considered important to business customers and determinants of bank selection in Kuwait: a segmentation analysis. International Journal of Bank Marketing, 15(4), 126-133.

[6]. FRB. (2012). Current use of mobile banking and payments. www.federalreserve.gov/econresdata/mobile-devices/2012-current-use-mobile-banking-payments.htm.

[7]. Govender, I., & Sihlali, W. (2014). A Study of Mobile Banking Adoption among University Students Using an Extended TAM. Mediterranean Journal of Social Sciences, 5(7), 451.

[8]. IPSOS. (2012). Mobile internet and smartphone adoption statistics. available at: www. digitimes.com.tw/tw/dt/n/shwnws.asp?CnlID¼10andCat¼35 andCat1¼andid¼310528.

[9]. Kamakura, W.A., Wedel, M., De Rosa, F., & Mazzon, J.A. (2003). Cross-selling through database marketing: a mixed data factor analyzer for data augmentation and prediction. International Journal of Research in marketing, 20(1), 45-65.

[10]. Khobzi, H., Akhondzadeh-Noughabi, E., & Minaei-Bidgoli, B. (2014). A New Application of RFM Clustering for Guild Segmentation to Mine the Pattern of Using Banks'e-Payment Services. Journal of Global Marketing, 27(3), 178-190.

[11]. Koenig-Lewis, N., Palmer, A., & Moll, A. (2010). Predicting young consumers' take up of mobile banking services. International Journal of Bank Marketing, 28(5), 410-432.

[12]. Laukkanen, T. (2007). Internet vs mobile banking: comparing customer value perceptions. Business Process Management Journal, 13(6), 788-797.

[13]. Lee, K., & Chung, N. (2009). Understanding factors affecting trust in and satisfaction with mobile banking in Korea: A modified DeLone and McLean's model perspective. Interacting with computers, 21(5), 385-392.

[14]. Mäenpää, I. (2012). Drivers of cross-sectoral cross-buying behaviour among business customers. International Journal of Bank Marketing, 30(3), 193-217.

[15]. Robinson, T. (2000). Internet banking: still not a perfect marriage. Informationweek. com, 4(17), 104-106.

[16]. Sangle, P.S., & Awasthi, P. (2011). Consumer's expectations from mobile CRM services: a banking context. Business Process Management Journal, 17(6), 898-918.

[17]. Thakur, R. (2014). What keeps mobile banking customers loyal? International Journal of Bank Marketing, 32(7).

[18]. Van den Berghe, L., & Verweire, K. (2001). Convergence in the financial services industry. Geneva Papers on Risk and Insurance. Issues and Practice, 173-183.

[19]. Wilcox, H. (2009). Banking on the mobile. white paper, Juniper Research, Basingstoke, available at www. juniperresearch. com (accessed 23 October 2009).

[20]. Wong, Y.K., & Hsu, C.J. (2008). A confidence-based framework for business to consumer (B2C) mobile commerce adoption. Personal and Ubiquitous Computing, 12(1), 77-84.

[21]. Zakrzewska, D., & Murlewski, J. (2005). Clustering algorithms for bank customer segmentation. Paper presented at the Intelligent Systems Design and Applications, 2005. ISDA'05. Proceedings. 5th International Conference on.

[22]. Zuccaro, C., & Savard, M. (2010). Hybrid segmentation of internet banking users. International Journal of Bank Marketing, 28(6), 448-464.

★★★

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

[1]YU-PIN LIAO, [2]SHIN-KUAN CHIU

[1]Chairman's Office, Winstar Display Corp., Taichung, Taiwan
[2]Ph.D. Program of Business, Feng Chia University, Taichung, Taiwan ,
[3]Department of International Trade, Feng Chia University, Taichung, Taiwan
E-mail: [1]panjc@winstar.com.tw, [2]skchiu@fcu.edu.tw

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 F ORECASTING M ETHODS . (○: 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., *p* 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:

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

$$\mathbf{b}_i \sim N(\mathbf{0}, \boldsymbol{\Psi}), \boldsymbol{\varepsilon}_i \sim N(\mathbf{0}, \boldsymbol{\Lambda}_i), \qquad (2)$$

where $\mathbf{b}_i$ is a matrix that is independent of $\boldsymbol{\varepsilon}_i$ (index i denotes the ith group at a single level), $\mathbf{y}_i$ contains n_i observation values for the ith 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:

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

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 $\boldsymbol{\beta}$ 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 $X_i\beta$ (i.e., $E(\mathbf{y}_i)=\mathbf{X}_i\boldsymbol{\beta}$). Because the covariance matrix of y_i is V_i (i.e., $Var(\mathbf{y}_i)=\mathbf{V}_i$) 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:

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

The ML function is expressed as follows:

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

where $\boldsymbol{\theta}$ denotes the set of $\mathbf{V}_1,...,\mathbf{V}_M$. 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 $l(\boldsymbol{\beta},\boldsymbol{\theta})=\ln L(\boldsymbol{\beta},\boldsymbol{\theta})$.

ML estimation method The ML estimates of β and θ are the values that maximize $l(\boldsymbol{\beta},\boldsymbol{\theta})$ and thus are also the values that maximize L(β,θ). Calculating the maximum value of $l(\boldsymbol{\beta},\boldsymbol{\theta})$ is challenging. Typically, let $\boldsymbol{\theta}=\hat{\boldsymbol{\theta}}$, and evaluate the value of β such that it maximizes $l_{\boldsymbol{\theta}=\hat{\boldsymbol{\theta}}}(\boldsymbol{\beta},\boldsymbol{\theta})$. Subsequently, let $\boldsymbol{\beta}=\hat{\boldsymbol{\beta}}$, and calculate the value of θ such that it maximizes the value of $l_{\boldsymbol{\beta}=\hat{\boldsymbol{\beta}}}(\boldsymbol{\beta},\boldsymbol{\theta})$. This process is iterated until the change in $\hat{\boldsymbol{\beta}}$ and $\hat{\boldsymbol{\theta}}$ is within a tolerance error (i.e., the $\hat{\boldsymbol{\beta}}$ and $\hat{\boldsymbol{\theta}}$ values converge).

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

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

Accordingly, $l_{\boldsymbol{\theta}=\hat{\boldsymbol{\theta}}}(\hat{\boldsymbol{\beta}},\boldsymbol{\theta})$ is the maximum value. Next, fix $\boldsymbol{\beta}$ in $l(\boldsymbol{\beta},\boldsymbol{\theta})$ as $\hat{\boldsymbol{\beta}}$, denoted by $l_{\boldsymbol{\beta}=\hat{\boldsymbol{\beta}}}(\boldsymbol{\beta},\boldsymbol{\theta})$, to obtain a $\boldsymbol{\theta}$ that maximizes the value of $l_{\boldsymbol{\beta}=\hat{\boldsymbol{\beta}}}(\boldsymbol{\beta},\boldsymbol{\theta})$, where

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

where $\mathbf{V}_1,...,\mathbf{V}_M$ are functions of $\boldsymbol{\theta}$. Typically, $l_{\boldsymbol{\beta}=\hat{\boldsymbol{\beta}}}(\boldsymbol{\beta},\boldsymbol{\theta})$ is not a linear function for $\boldsymbol{\theta}$. Consequently, no analytical solution for $\boldsymbol{\theta}$ exists, and an algorithm must therefore be used to obtain a numerical solution for $\boldsymbol{\theta}$. 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 $\boldsymbol{\theta}$ (i.e., $\hat{\boldsymbol{\theta}}$), 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 $\hat{\boldsymbol{\beta}}$ and $\hat{\boldsymbol{\theta}}$ converge.

REML estimation method The REML method is another approach for estimating $\boldsymbol{\theta}$. The REML estimate of $\boldsymbol{\theta}$ is obtained by applying an iterative method to a restricted natural-logarithm ML function.

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

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 $\boldsymbol{\theta}$ obtained using the REML is an unbiased estimator. The REML method involves applying Equation (4) to obtain the estimator of $\boldsymbol{\beta}$. For the REML, Equations (4) and (6) are iteratively used until the values of $\hat{\boldsymbol{\beta}}$ and $\hat{\boldsymbol{\theta}}$ converge. Equation (4) is used in both the ML and REML estimation methods to estimate $\boldsymbol{\beta}$. However, the functions employed to estimate θ (i.e., the ML and REML methods use Functions (4) and (6) to estimate $\boldsymbol{\theta}$, respectively) differ between these methods, and they thus yield different values for $\hat{\boldsymbol{\theta}}$. 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):

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

where "$\overset{d}{=}$" 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 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.

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

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

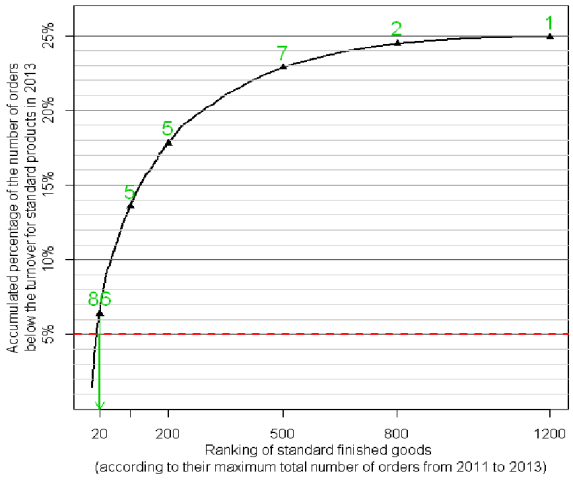

Figure 1. Maximum total number of orders (2011–2013). The plot shows that the accumulated percentage of the maximum total number of orders from 2011 to 2013 is less than the turnover of standard products in 2013. The first 20 products accounted for approximately 20% of the turnover for of standard products. 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:

$$\begin{aligned}\mathbf{y}_i &= \beta_0 + \beta_1 \times (\text{year-2007}) \\ &+ \beta_2 \times (\text{year-2007})^2 + \text{month} \times \boldsymbol{\beta}_3 \\ &+ b_{i0} + b_{i1} \times (\text{year-2007})^2 + \boldsymbol{\varepsilon}_i\end{aligned} \quad (8)$$

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 $\boldsymbol{\beta}=[\beta_0\ \beta_1\ \beta_2\ \boldsymbol{\beta}_3^T]^T$ is a 14 × 1 vector, where $\boldsymbol{\beta}_3$ 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, $\hat{\boldsymbol{\beta}}$ 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:

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

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, $j = 1,...,1295$) 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 ith order autoregressive process coefficient, B is a backward shift operator, θ_i is the ith 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 $\boldsymbol{\varepsilon}_i$ 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 $\hat{Y}_t \le 0$, then $F_t = 0$. Some link functions in generalized linear mixed-effect model can deal with the case where dependent variable is restricted to $\hat{Y}_t \ge 0$ [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.

REFERENCES

[1] P. Danese and M. Kalchschmidt, "The role of the forecasting process in improving forecast accuracy and operational performance," International Journal of Production Economics, vol. 131, no. 1, pp. 204-214, 2011.

[2] I. J. Adan and J. Van der Wal, "Combining make to order and make to stock," Operations-Research-Spektrum, vol. 20, no. 2, pp. 73-81, 1998.

[3] T. Williams, "Special products and uncertainty in production/inventory systems," European Journal of Operational Research, vol. 15, no. 1, pp. 46-54, 1984.

[4] W. M. Guillot, "Strategic leadership: Defining the challenge," Air and Space Power Journal, vol. 4, 2003.

[5] R. R. Magee, "Strategic leadership primer," DTIC Document, Tech. Rep., 1998.

[6] S. A. Shambach, "Strategic leadership primer," DTIC Document, Tech. Rep., 2004.

[7] R. Blackburn, K. Lurz, B. Priese, R. Gob, and I.-L. Darkow, "A predictive analytics approach for demand forecasting in the process industry," International Transactions in Operational Research, 2014.

[8] C. A. Soman, D. P. Van Donk, and G. Gaalman, "Combined make-to-order and make-to-stock in a food production system," International Journal of Production Economics, vol. 90, no. 2, pp. 223–235, 2004.

[9] W. Popp, "Simple and combined inventory policies, production to stock or to order?" Management Science, vol. 11, no. 9, pp. 868–873, 1965.

[10] L. C. Hendry and B. Kingsman, "Production planning systems and their applicability to make-to-order companies," European Journal of Operational Research, vol. 40, no. 1, pp. 1–15, 1989.

[11] S. Rajagopalan, "Make to order or make to stock: model and application," Management Science, vol. 48, no. 2, pp. 241–256, 2002.

[12] M.-K. Chen and A. Cheng, "The study of supply chain inventory strategy under bto production environment," Journal of the Chinese Institute of Industrial Engineers, vol. 20, no. 4, pp. 398–410, 2003.

[13] L. Breiman., "Statistical modeling: The two cultures (with comments and a rejoinder by the author)," Statistical Science, vol. 16, no. 3, pp. 199–231, 2001.

[14] C. C. Holt, "Forecasting seasonals and trends by exponentially weighted moving averages," International Journal of Forecasting, vol. 20, no. 1, pp. 5–10, 2004.

[15] J. F. Muth, "Optimal properties of exponentially weighted forecasts," Journal of the american statistical association, vol. 55, no. 290, pp. 299–306, 1960.

[16] F. Chen, J. K. Ryan, and D. Simchi-Levi, "The impact of exponential smoothing forecasts on the bullwhip effect," Naval Research Logistics, vol. 47, no. 4, pp. 269–286, 2000.

[17] S. C. Graves, "A single-item inventory model for a nonstationary demand process," Manufacturing & Service Operations Management, vol. 1, no. 1, pp. 50–61, 1999.

[18] R. Gob, K. Lurz, and A. Pievatolo, "Electrical load forecasting by exponential smoothing with covariates," Applied Stochastic Models in Business and Industry, vol. 29, no. 6, pp. 629–645, 2013.

[19] S. Wang, "Exponential smoothing for forecasting and Bayesian validation of computer models," Ph.D. dissertation, Georgia Institute of Technology, 2006.

[20] G. E. Box, "Time series analysis: Forecasting and control,," Time Series and Digital Processing, 1976.

[21] G. E. Box and G. C. Tiao, "Intervention analysis with applications to economic and environmental problems," Journal of the American Statistical association, vol. 70, no. 349, pp. 70–79, 1975.

[22] A. Pankratz, "Forecasting with dynamic regression models," Wiley Series in Probability and Mathematical Statistics. Applied Probability and Statistics, New York: Wiley, 1991, vol. 1, 1991.

[23] L. C. Hamilton and D. Press, Regression with graphics: A second course in applied statistics. Duxbury Press Belmont, CA, 1992, vol. 1, no. 1.

[24] J. G. De Gooijer and R. J. Hyndman, "25 years of time series forecasting," International journal of forecasting, vol. 22, no. 3, pp. 443–473, 2006.

[25] P. Hiesl and J. G. Benjamin, "Estimating processing times of harvesters in thinning operations in maine," Forest Products Journal, 2014.

[26] M. L. Bourbonnais, T. A. Nelson, M. R. Cattet, C. T. Darimont, G. B. Stenhouse, and D. M. Janz, "Environmental factors and habitat use influence body condition of individuals in a species at risk, the grizzly bear," Conservation Physiology, vol. 2, no. 1, p. cou043, 2014.

[27] Y.-C. Tsai, Y.-W. Chiu, J.-C. Tsai, H.-T. Kuo, S.-C. Lee, C.-C. Hung, M.-Y. Lin, S.-J. Hwang, M.-C. Kuo, and H.-C. Chen, "Association of angiopoietin-2 with renal outcome in chronic kidney disease," PloS one, vol. 9, no. 10, p. e108862, 2014.

[28] T. G. Holmes, W. M. Tonn, C. A. Paszkowski, and G. J. Scrimgeour, "Effects of winter surface aeration on pelagic zooplankton communities in a small boreal foothills lake of alberta, canada," Journal of Freshwater Ecology, no. ahead-of-print, pp. 1–14, 2014.

[29] N. Mohsin, G. Mourad, M. Faure, I. Szawarc, and J. Bringer, "Metabolic syndrome performs better than the individual factors in predicting renal graft outcome," in Transplantation proceedings, vol. 45, no. 10. Elsevier, 2013, pp. 3517–3519.

[30] A. Schwalm, Y.-S. Feng, J. Moock, and T. Kohlmann, "Differences in eq-5d-3l health state valuations among patients with musculoskeletal diseases, health care professionals and healthy volunteers," The European Journal of Health Economics, pp. 1–13, 2014.

[31] Y. Acar and E. S. Gardner, "Forecasting method selection in a global supply chain," International Journal of Forecasting, vol. 28, no. 4, pp. 842–848, 2012.

[32] P. G. Allen and B. J. Morzuch, "Twenty-five years of progress, problems, and conflicting evidence in econometric forecasting. what about the next 25 years?" International Journal of Forecasting, vol. 22, no. 3, pp. 475–492, 2006.

[33] R. Fildes, "The forecasting journals and their contribution to forecasting research: Citation analysis and expert opinion," International Journal of forecasting, vol. 22, no. 3, pp. 415–432, 2006.

[34] J. C. Pinheiro and D. M. Bates, Mixed-effects models in S and S-PLUS. Springer Science & Business Media, 2000.

[35] B. T. West, K. B. Welch, and A. T. Galecki, Linear mixed models: a practical guide using statistical software. CRC Press, 2014.

[36] N. M. Laird and J. H. Ware, "Random-effects models for longitudinal data," Biometrics, pp. 963–974, 1982.

[37] N. Laird, N. Lange, and D. Stram, "Maximum likelihood computations with repeated measures: application of the EM algorithm," Journal of the American Statistical Association, vol. 82, no. 397, pp. 97–105, 1987.

[38] M. J. Lindstrom and D. M. Bates, "Newton Raphson and EM algorithms for linear mixed-effects models for repeated-measures data," Journal of the American Statistical Association, vol. 83, no. 404, pp. 1014–1022, 1988.

[39] P.-F. Pai, K.-P. Lin, and J.-S. Wang, "Stock price forecasting in Taiwan using ellipsoidal fuzzy system," Journal of the Chinese Institute of Industrial Engineers, vol. 21, no. 2, pp. 146–155, 2004.

[40] W.-Y. Hwang and J.-S. Lee, "A new forecasting scheme for evaluating long-term prediction performances in supply chain management," International Transactions in Operational Research, vol. 21, no. 6, pp. 1045–1060, 2014.

[41] Y. Cao, G. Wan, and F. Wang, "Predicting financial distress of Chinese listed companies using rough set theory and support vector machine," Asia-Pacific Journal of Operational Research, vol. 28, no. 01, pp. 95–109, 2011.

[42] F. B. e Silva, E. Koomen, V. Diogo, and C. Lavalle, "Estimating demand for industrial and commercial land use given economic forecasts," PloS one, vol. 9, no. 3, p. e91991, 2014.

[43] X. Zhang, T. Zhang, A. A. Young, and X. Li, "Applications and comparisons of four time series models in

epidemiological surveillance data," PloS one, vol. 9, no. 2, p. e88075, 2014.
[44] J. Jiang, Linear and generalized linear mixed models and their applications. Springer Science & Business Media, 2007.
[45] D. R. Cox, "Prediction intervals and empirical Bayes confidence intervals," Perspectives in Probability and Statistics, pp. 47–55, 1975.
[46] C. Morris, "Parametric empirical Bayes inference: theory and applications," Journal of the American Statistical Association, vol. 78, no. 381, pp. 47–55, 1983.
[47] R. Basu, J. K. Ghosh, and R. Mukerjee, "Empirical Bayes prediction intervals in a normal regression model: higher order asymptotics," Statistics & probability letters, vol. 63, no. 2, pp. 197–203, 2003.
[48] S. Chatterjee, P. Lahiri, and H. Li, "On small area prediction interval problems," The Annals of Statistics, vol. 36, pp. 1221–1245, 2008.
[49] M. Yoshimori, and P. Lahiri, "A second-order efficient empirical Bayes confidence interval," The Annals of Statistics, vol. 42, no. 4, pp. 1–29, 2014.

★★★

A COMPARATIVE STUDY BETWEEN DIFFERENT TYPES OF TEMPERATURE SENSOR

[1]ABBA MOHAMMED, [2]SULEIMAN BABANI, [3]ABDURRASHID IBRAHIM SANKA, [4]NURA AHMED ABDULLAHI

[1]Department of Electrical and Electronics Engineering, College of Engineering,
[2]Hussaini Adamu Federal Polytechnic, P.M.B 5004 Kazaure, Jigawa State, Nigeria
[3]Department of Electrical Engineering, Bayero University, Kano, Nigeria
[4]Jigawa State Institute of Information Technology Kazaure, Computer Engineering Department
E-mail: [1]abba.munirgumel@gmail.com, [2]sbabani2000@gmail.com, [3]aisanka.ele@buk.edu.ng, [4]annur_ring@yahoo.com

Abstract- Understanding the characteristics of different types of temperature sensor will enable the user to select the proper temperature sensor for reliable temperature measurement. In this paper, Thermocouple, Thermistor, Resistance temperature detector, Pyrometer and LM35 temperature sensors are evaluated and compared in respect of their advantages and disadvantages based on accuracy, response, range, cost and application areas.
.

Index Terms- Pyrometer, RTDs, Sensor, Thermocouple, Thermistor.

I. INTRODUCTION

The most basic definition of temperature sensor devices is that they are tools specially designed to measure the hotness or coolness of an object. However, sensors are actually measuring the atomic activity and movement of an object. When temperature sensor devices read an object with zero atomic activity, the temperature point is considered absolute zero. When a substance is heated, it usually moves through several phases: solid to liquid and from liquid to gas until the atomic activity begins increasing. [1]

II. TYPES OF TEMPERATURE SENSOR

THERE ARE TWO BASIC TYPES OF TEMPERATURE SENSORS:

Contact Sensors – This type of sensor requires direct physical contact with the object or media that is being sensed. They supervise the temperature of solids, liquids and gases over a wide range of temperatures.
Non-contact Sensors – This type of sensor does not require any physical contact with the object or media that is being sensed. They supervise non-reflective solids and liquids but are not useful for gases due to natural transparency. These sensors use Plank's Law to measure temperature. This law deals with the heat radiated from the source of heat to measure the temperature [2]

A. Examples of Contact Temperature Sensor
- Thermocouples
- Resistance Temperature Detectors (RTDs)
- Thermistors
- IC Temperature Sensors (LM35)
- Bimetallic etc.

B. Example of Non-contact Temperature sensor
- Optical Pyrometer

III. THERMOCOUPLE

A Thermocouple is a sensor used to measure temperature. Thermocouples consist of two wire legs made from different metals. The wires legs are welded together at one end, creating a junction. This junction is where the temperature is measured. When the junction experiences a change in temperature, a voltage is created. [3]

In 1821 Thomas Johann Seebeck (1770-1831) noticed that, if two wires from different material are connected at their endings performing two different junctions, and these junctions do not have the same temperature, then placing these wires near by a compass, would cause the compass to move. At first he believed that the temperature is the reason to change the magnetic field. Later on, he understood that a current was flowing within the wires that generated a magnetic field and moved the compass. That is called the thermoelectric effect or Seebeck effect. [4]
Figure 1. Shows a Thermocouple circuit

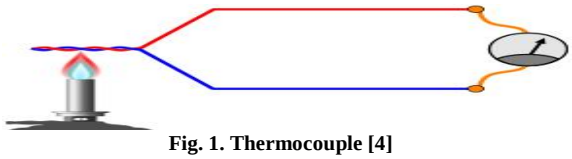

Fig. 1. Thermocouple [4]

C. Advantages
Self-Powered
- Rugged
- Low cost
- Wide Temperature Range
- High Temperature limits [5]

D. Disadvantages
- Non Linear
- Low Voltage
- Least stable [5]

Thermocouples are made of different types of wire and have very different properties, making one type better for a specific application than another. The descriptions of the types of thermocouples are shown in table 1.

Type	Materials	Min temp	Max temp	Min°C	Max°C
J	Iron Constantan(Cu-Ni)	0°C	750°C	0 mV	42.281 mV
T	Copper Constantan(Cu-Ni)	-250°C	350°C	-6.18 mV	17.819 mV
K	Cromel (Ni-Cr) Alumel (Ni- Al)	-200°C	1250°C	-5.891 mV	50.644 mV
E	Cromel (Ni-Cr) Constantan(Cu-Ni)	-200°C	900°C	-8.825 mV	68.787 mV
N	Nicrosil (Ni-Cr-Si) NiSil (Ni-Si-Mg)	-260°C	1300°C	-4.336 mV	47.513 mV
S	Platinum-13% Rhodium Platinum	-50°C	1768°C	-0.236 mV	18.693 mV
B	Platinum-30% Rhodium Platinum-6% Rhodium	0°C	1820°C	0 mV	13.82 mV
C	Tungsten-5% Rhenium Tungsten-26% Rhenium	0°C	2320°C	0 mV	37.107 mV

Table 1. Description of different types of thermocouple [6]

E. Thermocouples are used in many industrial, scientific, and OEM applications. They can be found in nearly all industrial markets: Power Generation, Oil/Gas, Pharmaceutical, Biotech, Cement, Paper & Pulp, etc. Thermocouples are also used in everyday appliances like stoves, furnaces, and toasters. [3]

IV. THERMISTOR

The **Thermistor** is another type of temperature sensor, whose name is a combination of the words THERM-ally sensitive res-ISTOR. A thermistor is a special type of resistor which changes its physical resistance when exposed to changes in temperature. Most types of thermistor's have a Negative Temperature Coefficient of resistance or (NTC), that is their resistance value goes DOWN with an increase in the temperature, and of course there are some which have a Positive Temperature Coefficient, (PTC), in that their resistance value goes UP with an increase in temperature. [7]



Fig. 2. Thermistors [8]

A. Advantages
- High output
- Fast response

B. Disadvantages
- Fragile
- Current source required
- Self-heating
- Limited temperature range
- Non-linear [10]

C. Applications
- Textile production
- Plastics processing
- Petro-chemical processing
- Air, gas and liquid temperature measurement [11]

V. RESISTANCE TEMPERATURE DETECTORS

Resistance Temperature Detectors (RTDs) are temperature sensors that contain a resistor that changes resistance value as its temperature changes. They have been used for many years to measure temperature in laboratory and industrial processes [9] RTDs are used to measure temperatures from -196° to 482° C (-320° to 900° F) [10]



Fig. 3. Resistance temperature device [7]

A. Advantages
- Most stable
- Most accurate
- More linear than thermocouple [10]

B. Disadvantages
- Expensive
- Less-rugged than thermocouple
- Current source required [10]

C. Applications
- Air conditioning and refrigeration servicing
- Food Processing
- Stoves and grills
- Textile production
- Plastics processing
- Petrochemical processing
- Micro electronics
- Air, gas and liquid temperature measurement
- Exhaust gas temperature measurement [11]

VI. PYROMETER

A pyrometer is used to measure the temperature of an object from a distance, without making contact. The method used for making these non-contacting temperature measurements is known as radiation

pyrometer. Non-contact temperature sensors use the concept of infrared radiant energy to measure the temperature of objects from a distance. After determining the wavelength of the energy being emitted by an object, the sensor can use integrated equations that take into account the body's material and surface qualities to determine its temperature. [12]

A. Advantages

- Hand-held and easy to use
- Very accurate and precise
- Quick (1-2 second) response time
- No contact with target object is necessary
- Excellent for high temperature and moving objects
- Non-contact type
- Can monitor movable object
- Portable [13]

B. Disadvantages

- Not useful for measuring temperature of clear gas
- At high temperature, filament erodes frequently
- Expensive
- Optical pyrometers require an operator for use
- Almost impossible to check error of measurement
- Accuracy easily affected by dust, smoke, and background radiation [13]

C. Applications

Pyrometers are most useful for measuring the temperature of objects that are at high temperature, moving, surrounded by an electromagnetic field, or in a controlled environment. They are commonly used for racecar tires, pottery kilns, steel mills, steam traps, and semiconductors. [13]. Figure 4 shows a pyrometer.



Fig. 4. Pyrometer [15]

VII. IC TEMPERATURE SENSORS (LM35)

The LM35 is an integrated circuit sensor that can be used to measure temperature with an electrical output proportional to the temperature (in ^{o}C), it is with high precision and wide linear working range, the output voltage is proportional to temperature, when the temperature increase 1Celsius degree, output voltage increase 10mV. It is commonly used as a temperature measurement sensors. Rated operating temperature range: - 55 ~ + 150 °C.

A. Advantages

- Linear output
- Analog or digital output available
- Direct voltage, current
- Low cost

B. Disadvantages

- Narrow Temperature range -55 to 150 °C [14]

C. Applications

- Used for measuring temperature below 150 °C

CONCLUSION

A comprehensive comparison between five different types of temperature sensor is presented. It was shown that each sensor has its own unique features and characteristics. Therefore the decision upon which temperature sensor to use will depend on the range of the temperature to be measured and the application areas of the device.

REFERENCES

[1].http://www.devale.com/temperature-sensor/temperature-sensin g.html

[2]. http://www.engineersgarage.com/articles/sensors?page=2

[3] http://www.thermocoupleinfo.com/

[4] http://www.pcbheaven.com/wikipages/How_Thermocouples_Work/

[5] http://www.appliedsensortech.com/pdf/sensor_overview.pdf

[6]http://www.utrm.rub.de/doc/fachlabor/skript_en_temperature-laboratory.pdf

[7] http://www.electronics-tutorials.ws/io/io_3.html

[8] http://www.marbef.org/wiki/Temperature_sensors

[9] http://www.omega.com/temperature/pdf/rtd_gen_specs_ref.pdf

[10] http://www.ueonline.com/temperature-sensors.html

[11]https://www.watlow.com/products/guides/sensor/sesg_con.cfm?famid=341

[12]https://www.arm.gov/education/studyhall/ask/past_question.php?id=599

[13]http://encyclopedia.che.engin.umich.edu/Pages/ProcessParameters/TemperatureMeasurement/TemperatureMeasurement.html

[14] http://robotbase.en.alibaba.com/product/367689779-211851701/LM 35_Linear_Temperature_Sensor.html

[15]https://www.google.com.ng/search?q=pyrometer&biw=1366&bih=631&source=lnms&tbm=isch&sa=X&sqi=2&ved=0CAYQ_AUoAWoVChMIhIiwzqb1xwIV8wrbCh1akwoC&dpr=1

★★★