MANAGEMENT EDUCATION IN NEPAL: STATUS, SPATIAL DISTRIBUTION AND GENDER DIVERSITY

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Abstract— Development of management education is fairly new phenomenon in Nepal. Within a life of about six decades it has witnessed many important developmental phases. As of 2009/10 a total of 568 institutions are providing higher education in management and the number is expected to increase further as Nepal has adopted multi-university policy and invited private sectors and communities to invest in education development. With the increasing global competitiveness because of globalization and technological advancement, management education in Nepal is struggling meet the standard. This paper analyzes status and spatial distribution of management institutions and gender diversity of management students in Nepal. The results conclude that management institutions are confined in the central region, dominated by private sectors in numbers of institutions while public institutions hold more than 80 percent students and gender disparity is decreasing but still males are dominating.

I. BACKGROUND

This paper primarily addresses four major objectives. First, it briefly summarizes the development of management education in Nepal. Second, it shades lights on spatial distribution of management education institutions. Third, it makes analysis of the involvement of public, community and private sectors. Fourth, it summarizes key status on gender diversity in management students.

Nepal's education system is comparatively less exposed to international market because of two major reasons. First, development of modern education system in Nepal is recent phenomenon, particularly in the second half of twentieth century only. Second, there are serious concerns on the quality of educational systems in Nepal. In the last half century Nepal witnessed remarkable quantitative growth in educational institutions but the quality could not accompany the quantitative growth. Nepal's education system also critically suffers from lack of innovation and more dependent to imitation, particularly with Indian system of education. For instance, the first modern higher education institution, Tri-Chandra College, was established in 1918 with affiliation to Calcutta University and later to Patna University. For number of years Patna University supported to develop curriculum and conduct final examinations.

This paper is an attempt to bring out some important aspects of Nepal's education systems and practices, particularly in the area of management education. Management education is one of the popular education streams. There is increasing interest of young generations in this field and as a response many management institutions are coming into market through government, community and private efforts. In the first section of this paper briefly summarizes the development of management education in Nepal. However, the focus is on the second part which highlights spatial distribution of management institutions in the context that Nepal has adopted decentralizing the education facilities and services. The paper further analyzes public, private and community participation in management education. The idea of this analysis is to find the key players in management education in Nepal and acknowledge their roles. In the context that Nepal has officially adopted social inclusion policy in every public affair, government is taking initiatives to reduce gender imbalance in higher education. This paper also offers some evidences on this regards.

II. MANAGEMENT EDUCATION IN NEPAL

Although, modern higher education in Nepal was started in 1918, the management education began only in September 1954 when Tri-Chandra College, the first college on the country, launched Intermediate of Commerce (I. Com) and Bachelor of Commerce (B. Com) with 27 and 4 students respectively (Acharya, 2011). However, the master level education in management was offered only in 1960 after establishment of Tribhuvan University (TU), the first university of Nepal. Establishment of TU in 1959 brought many hopes in development of higher education of Nepal. It opened avenues for public participation in home grown higher education system and was therefore important to note because, at that time, Nepal was recently freed from century long family dictatorship which used to see public education as threat for them.

As another milestone, the New Education Plan System (NEPS) 1971 strengthened the higher education development in Nepal. The NEPS revolutionized the higher education including management education by revising curriculum structure, examination system and quality enhancement. TU started expanding it coverage outside Kathmandu valley and different parts of country. The establishment of Faculty of Management (FoM) under TU in mid 1980s gave a new shape to development of management education in Nepal.

Compared to other South Asian countries, Nepal's management education is relatively new. It started in mid 1950s and has particularly gained momentum after 1990s. The decade of 1990s was instrumentally important in education development of Nepal. The first elected democratic government in 1992, after restoration of multiparty democracy in 1991, opened up opportunities for private and community involvement in higher education through its new market-based economic policy. Thereafter, new universities and education institutions came into market to provide higher education in Nepal. In the country with 26.4 million population, crippled economy and gloomy business faces, history of management education has observed ups and down since its beginning. At present, Nepal has 8 universities and 2 higher education institutions of which 8 are functional, only 4 are providing higher education in management and 2 are planning to start soon. Besides, some institutions affiliated with foreign universities are also providing management education. Although there are differences in exact number of management education institutions, as of 2008/2009 University Grants Commission Nepal, there were 411 functional management education institutions affiliated to national universities of Nepal (University Grants Commission [UGC], Nepal, 2011) which constituted around 32 percent of total higher education institutions. The number of management institutions increased to 568 by 2009/10 comprising 37.2 percent of the total higher education institutions (UGC, 2012) [1], the largest proportion.

In Nepal, higher education in management is provided through four levels- intermediate, bachelor, master, MPhil and PhD level. Recent education policy of Nepal has phased-out intermediate level from university education and merged with higher secondary education. Therefore, management education in university level is provided in three major levels. At the initial phase of management education, the course was merely confined in teaching of some theoretical issues of commerce and business. The scope was narrow. However, with the increase of management institutions, the scope, nature, structure and coverage has increased remarkably. Now, management education does not mean only the theories of commerce and business, it is more about managing the enterprises, office, employees, human resources, finding innovation in economy and market. There are wide varieties of course depending on the market demands in each level and students are allowed to select the subjects of their interest. There are more than 20 management courses offered at bachelor and master level. There is growing strengths of management education institutions in terms of infrastructure, faculty, resources including library facilities and research activities and networks within and out-side county.

III. SPATIAL DISTRIBUTION OF MANAGEMENT INSTITUTIONS IN NEPAL

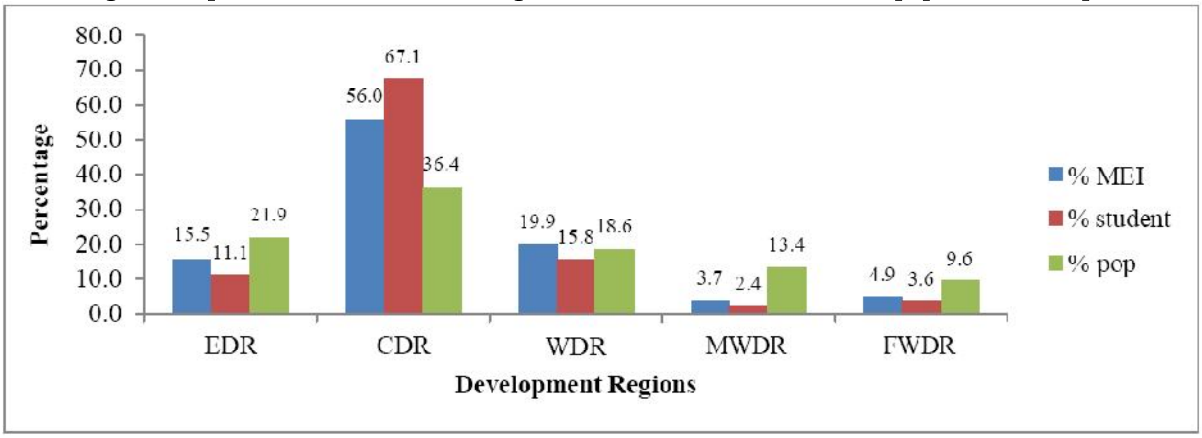
Despite having policy of decentralizing education institutions, Nepal's education system is highly centralized. This study is based on the 568 management education institutions affiliated to national universities of Nepal (as of 2009/10). It shows that 56.0 percent of management institutions are located in the central region, followed by western region (19.9%), eastern region (15.5%), far-western (4.9%) and the least in mid-western (3.7%). While in-terms of distribution of students, central region holds slightly more than two-thirds students, followed by western region (15.8%), eastern region (11.1%), far-western (3.6%) and mid-western region (2.4%) (Figure 1).

This distribution configures the domination of central region in both number of institutions and students. Within central region, Kathmandu valley alone occupies a large majority of management institutions and students. To some extent, it seems obvious because of three major reasons. First, Kathmandu is the capital city which is also the economic and political capital. Second, given the political, economic and social opportunities, Kathmandu valley remained safe place for the investment in education institutions. Third, it is also the result of unitary and centralized governance system. Although Nepal has principally and concretely adopted decentralization policy by adopting the Decentralization Plan 1965, it remained futile until recent (Dahal, Uprety, & Subba, 2001). Only some concrete examples were observed after 1990s. The state was inherently limited within the capital city and some other few major cities. It was discouraging factor for growth of educational institutions beyond Kathmandu valley.

Figure 1 shades more lights on the concentration of management institutions and students compared to population distribution in the respective areas. It is apparent that central region over-represents management institutions and students in comparison to population in that area, the difference is around 20 percent points, whereas in all other areas are underrepresented.

Interestingly, the proportion of students in central region is even higher than the proportion of institutions. This indicates that central region is popular education destination for students across Nepal.

Figure 1: Spatial distribution of management institutions, students and population of Nepal



Source: University Grants Commission [UGC], (2012); Central Bureau of Statistics [CBS],(2012)

Note: EDR= Eastern Development Region, CDR=Central Development Region, WDR=Western Development Region, MWDR=Midwestern Development Region, FWDR=Far-Western Development Region, MEI= management education institutions, pop=population.

Figure 1 generates three important messages on management education status in Nepal. First, there is high concentration of institutions and students in only central region creating an imbalance in distribution. This imbalance is a challenge for the government of Nepal to maintain regional balance. Second, such discrepancy challenges the quality of education. In some areas there is overflow of students whereas in others there is always shortage. The earlier has management problem while the later has sustainability. Third and important is increasing divide in the educational achievement of students. This is because institutions with better facilities, experienced faculties and opportunities are available only in central region, particularly in Kathmandu valley. Just opposite to this, the institutions operating in other regions are poorly managed, quality education is challenged and opportunities are limited.

As a matter of improvements, there are some important milestones in reducing regional imbalance in education facilities, particularly when the Government of Nepal (GoN) adopted multi-university concept and invited private sector to invest in education development. The GoN came up with the plan to open regional universities in order to reduce the imbalance and increase access of people in education within their convenient locality. As a landmark, Kathmandu University was founded in 1991 with private initiative as a first non-state university. This opened new avenues for involvement of private sector in higher education development. However, this university is also limited to provide service within Kathmandu valley and its nearest periphery.

Amidst growing demand of people for decentralization of education facilities, the GoN, for the first time, established Purbhanchal University in 1995 with a regional concept to provide quality education facilities to eastern Nepal. Following this, Pokhara University was established in 1996 to cater higher education facility to western Nepal. Recently, the GoN has opened three more universities (Lumbini Boudha University - western region, Mid-Western University, Far- Western University) with a regional concept in mid-western and far-western Nepal. Interestingly, the first choice of these universities is to provide higher education in management.

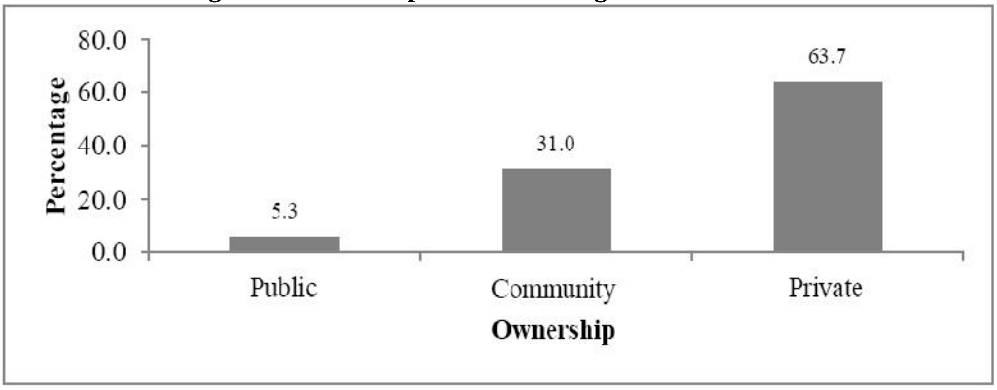
Despite the government's effort to decentralize educational services with establishing new universities at regional level, attraction to Kathmandu valley and some specific institutions within the valley remains unchallenged. And still it takes more time and efforts to develop management institutions outside valley to compete in national and international level.

IV. PUBLIC, COMMUNITY AND PRIVATE INVOLVEMENT

Higher education in management is provided by three types of educational institutions- public, community and private institutions. Public institutions imply constituent institutions of universities and they receive substantive public funds. The ownership of such institutions is under government. Community institutions are owned by the community and are non-profit organizations. They receive small public funds for their contribution in educational development. Private institutions are owned by a person or a group of promoters and may operate for profit. These institutions do not receive public funds. The classification of University Grants Commission Nepal 2011 is used throughout this paper.

Normally, education in Nepal was state controlled public services until recent. When the GoN adopted liberal mixed economy policy and allowed private sector to invest in higher education in early 1990s, investment in education became an attractive opportunity. Figure 2 shows that in terms of number of management institutions, private institutions are fairly dominating (63.7%), followed by community campuses (31.0%) while the proportion of government funded management institutions in around five percent. Earlier state controlled higher education service is now slowly slipping into the hands of private sectors and community because of two major reasons. First, the GoN has adopted a policy to allow private sector involvement into education services which encouraged them to increase investment in education. Investment in educational institutions is considered as secure and it is easy to start with small investment. Second, the quality of government owned institutions is continuously deteriorating because of unwanted political interference and poor management. As a result there is always a demand of quality and well-managed institutions. Private institutions are harvesting this sentiment. The higher number of community institutions is also a part of government policy. Government is also promoting community involvement in education so that community becomes responsible for ensuring the accessibility of quality education.

Figure 2: Ownership status of management institutions



Source: UGC Nepal, (2012)

If we observe the distribution across the development regions, we find an interesting pattern. Private institutions are more concentrated in central development region, followed by western region and eastern region. Their existence in mid-western and far-western region is relatively low. Community institutions are wide spread all over the country followed by public institutions but their presence in mid-western and far-western is not encouraging. It shows an obvious nature of private and public investment. Private investors always look for profit while public investment is for providing service to people and does not look for profit and loss.

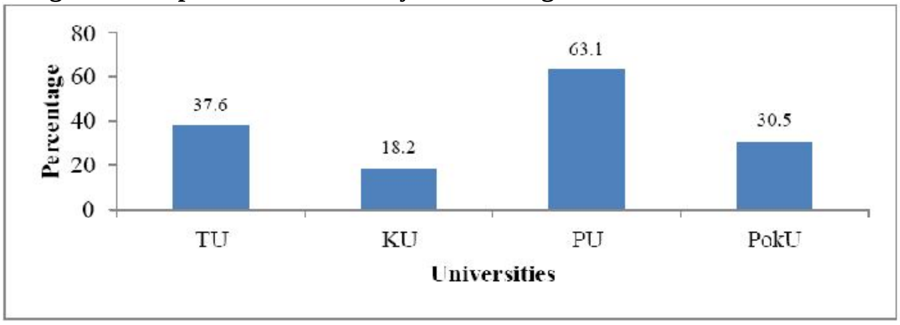
When we look in terms of student enrollment, the scenario is completely otherwise. The five percent public institutions hold about 41 percent of students while community institutions hold an equivalent proportion of students (34%). Private institutions only hold 26 of total students which is around 38 percent points less than their holding in number of institutions (UGC Nepal, 2012). This implies that although community and private institutions hold large share in management education institutions, their contribution in terms of number of students it still low. There is still large flow of students in public institutions because of three major reasons. First, private institutions are relatively expensive so that every one cannot afford it. In Nepal, large section of students come from low or lower middle economic class. Second, most of the private institutions are located in city, particularly in Kathmandu valley which is not accessible for all students from remote and distance area. Third, only a few private institutions are well known for quality education. These institutions have relatively small intake through competitive examinations. Except these institutions, student prefer to go either public or community institutions than other private institutions.

V. UNIVERSITY-WISE MANAGEMENT INSTITUTIONS

Only four universities of Nepal- Tribhuvan University (TU), Kathmandu University (KU), Purbanchal University (PU) and Pokhara University (PokU)- are providing higher education in management. There are two more home-grown universities - Mid-Western and Far-Western universities- established recently. These universities have just started their programme but we do not have concrete information. Therefore, in this analysis only four universities are included.

Among these universities, TU gets above 80 percent government subsidy and said to be state owned public university. Other universities, except KU, are designed to operate in cost sharing basis. However, KU was established in private initiatives and operating with self-revenue generation. Figure 3 shows distribution of management education institutions by universities.

Figure 3: Proportion of university-wise management education institutions



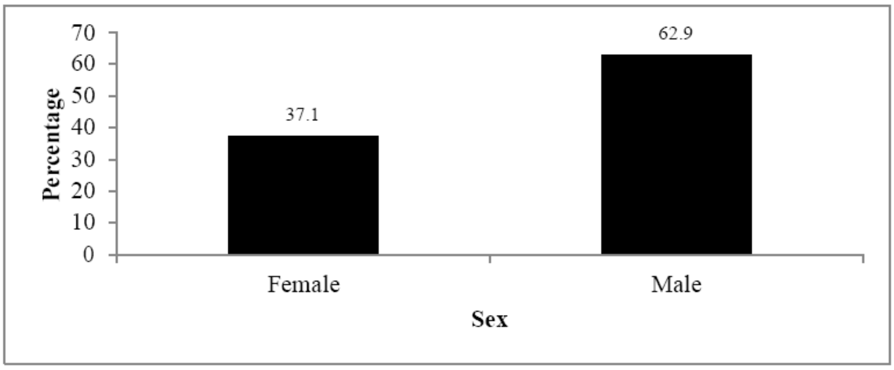
Source: UGC Nepal (2012)

More than three-fifths institutions of PU provide higher education on management followed by TU (37.6%), PokU (30.5%) and KU (18.2%). It shows that new universities have higher priority for management education. In terms of student number, TU is unabated since it alone holds more than 85 percent of students in management education (UGC, 2012). Among four universities, KU is established by private initiative. Therefore, all institutions under it are operated by private investment. Within other universities, PU and PokU have more than 90 percent private institutions while over half of the institutions with TU are private. The conclusion from this analysis is that management education is in priority for all universities. For promotion of management education role of private investment is inevitable. However, involvement of private sector is unable to significantly reduce burden in public institutions.

VI. GENDER DIVERSITY IN MANAGEMENT EDUCATION STUDENTS

Nepal has adopted inclusive development policy particularly after 1990s. Earlier education to females was restricted to a greater extent manifested by social, cultural, political and economic barriers and there was absolute domination of males in education. Now female participation in educational institution is cherished. Government has non-discriminatory but encouraging policy for increasing women participation in education. As one of the objectives of this study is to offer gendered analysis management students, female representation in management education is analyzed. Figure 4 broadly shows the sex-disaggregated distribution of management students. It reveals that still management education is under control of male students as male represent over three-fifths of total management students.

Figure 4: Sex-disaggregated distribution of management students



Source: UGC Nepal (2012)

Although, males hold a large majority of management students, female participation is remarkably increasing over the year. Management education is being popular among female students. In fact, management education comes into second choice after science and technology. However, for many bright students, management is becoming first choice. The UGC Report shows that the share of female students in higher education enrollment has increased from 35 percent in 2005/06 to 40.7 percent in 2009/10. However, it is not uniformly distributed throughout all level. As the level of education increases females' participation sharply decreases. For example, at the bachelor level the proportion of female is 38.4 percent which decreases to 31 percent at master's level to 14.6 percent at MPhil to 7.1 percent at PhD level. In terms of Gender Parity Index (GPI), management comes in third position with 0.6 after medicine and education faculty. However, it is still better than science and technology, law and engineering faculties (UGC Nepal, 2012) but not enough yet.

To look from other perspective, females' participation in community institutions is better than public and private institutions. If we take community and private institutions together as non- state institutions, they dominate public institutions in terms of percentage of girls' enrolment in management education. Nevertheless, that GPI is increasing gradually to reach 0.7 in 2009/10 from a low 0.5 in 2005/06 (UGC Nepal, 2012).

CONCLUSION

Management education in Nepal started in mid 1950s to produce qualified human resources for government organizations, financial companies and industrial sectors (Koirala, 2005). It gained momentum only at the last decade of 20th century. Nepal is characterized as a small country with small and sluggish economy and diverse population and geography, development of management education is surrounded by several challenges. Constrained in small domestic market size, management education in Nepal has to go a long way for quality and competitiveness (Rosenbloom & K.C., 2005). Despite government's policy to decentralize services and facilities including education, there is high concentration on central region, particularly in Kathmandu valley. It shows that educational facilities are not proportionately distributed across the country. There is not only quantitative discrepancy, qualitative differences are equally serious. Although, private sector involvement in management education is significant, it still largely remains under the purview of public institutions. However, emergence of community institutions is admirable for reducing the regional imbalance. Private sector involvement is significant in terms of number of institutions while their contribution in student size is still below the expected level. A new initiative is essential for bridging public, community and private institutions (Koirala, 2005) so that synergy effect can be sustained. Encouragingly, females' participation in management education is increasing but not equal to male counterparts showing a higher gender disparity.

This study has both academic and policy relevancies. In an academic domain, it provides a comparative and decomposed analysis that may be helpful for the students and researchers to understand the dynamics of management education in Nepal. It has policy input for the GoN for reviewing and assessing higher education policy in the present contested context of state restructuring where there are demands of decentralizing and devolving state services including education facilities in real terms. It also recommends for a policy initiative to create an environment for spatial and gender balance in management education. Private and community institutions need to think on increasing the coverage in terms of geography and students followed by quality and innovative management education. In this situation, Nepal should clearly spell out its strategic planning for the development of higher education (Khaniya, 2011) based on analysis of own experience.

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DEVELOPING A MASSIVE OPEN ONLINE COURSE BY CMAP-TOOL

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Abstract— This study explores how Concept Mapping helped to develop the content of a Massive Open Online Course. This course namely Decision Making is offered by Obuda University. The main objective of this course was to define the key concepts of decision making and helping contextualization of these concepts. A crucial aspect of developing this course was supporting the learning process by different types of materials, for example video lectures, texts and comic strips. Firstly some decision dilemmas were defined and an initial Cmap was created. Secondly some dramas was chosen to understand decision makers' catharsis and the initial Cmap was reconstructed. Thirdly some scenarios were prepared to comic strips. In every steps the reconstruction of Cmap helped to find the connections between the key concepts of decision making.

Index Terms— Cmap, Decision Making, Dilemmas, MOOC.

I. DECISION MAKING: BEYOND DISCIPLINE

There is a strong separation of disciplines, which is accepted, but never became popular. The labels of Sciences and Humanities suggest that certain disciplines are contained within science, but others are left out. There are sciences (physics and chemistry for example) and then there is philosophy. From these, one can craft philosophies of science (the philosophy of physics, the philosophy of chemistry), but it is foolish to try and create a science of philosophy (the physics of philosophy, the chemistry of philosophy). There is knowledge (disciplines) that can be taught and learned. Decision-making is one of them. The sciences can be turned into disciplines, but this does not work the other way around. One cannot make decision making into decision science. At the heart of soft disciplines lies the definition of the conceptual framework and model. Here the recognition of problems and the tentative search for their solutions are not repeatable. It is simply not possible to conduct the same experiment under the same conditions. For decades now, in the Balkans and its area, on the peripheries of the mainstream, the authors have been working on making sure that decision making does not become the stepchild of operation research, nor that of social- or cognitive psychology, or even of neurobiology.

The study of decision-making is beyond its teething problems, when it was imagined that algorithms, that is rigid sequences of operations, would remove all doubt. Applied operation research sets applied research aside, and develops useful algorithms, which optimize well-structured operations. A lot of players have weighed in on decision-making courses. Business schools and Schools of Economics prefer using models and methods. Referring to Thomas Sedláček[1], just because we can describe how something operates does not mean we understand the connections. Just because a story is told dressed in the garbs of mathematics, it is not robbed of its mystery. Business Schools have adopted the catchy phrases of operation researchers. Applied arithmetic is always "difficult" for mediocre people, and so it commands respect.

II. DECISION DILEMMAS

To develop the content of Decision Making Massive Open Online Course I outlined sixteen decision dilemmas. Risky vs. Unimaginable (1), Original vs. Imitation (2), Measurable vs. Immeasurable (3), Replaceable vs. Irreplaceable (4), Responsibility vs. Intellectual Integrity (5), Products vs. Hints (6), Facts vs. Interpretation (7), Consumtariat vs. Netocracy (8), Hope vs. Possibility (9), Pre-filter vs. Post-filter (10), Cool vs. Retro (11), False Urgency vs. True Urgency (12), Global vs. Local (13), Masses vs. Tribes (14), Integrated vs. Differentiated (15) and Resource vs. Human being (16). These dilemmas can be examine from two dimensions. First dimension is the possible role of decision takers'. These roles are Chief Executive Officer (CEO), Chief Innovation Officer (CIO), Chief Knowledge Officer (CKO) and Chief Human Resources Officer (CHO). Second dimension is the domain of decisions: new paradigm, new context, new validating and new identity. The sixteen decision dilemmas in the mentioned two dimensions are showed in Table I.

Table I: Decision dilemmas in two dimensions

	CEO	CIO	CKO	CHO
newparadigm	(1)	(2)	(3)	(4)
newcontext	(5)	(6)	(7)	(8)
newvalidating	(9)	(10)	(11)	(12)
newidentity	(13)	(14)	(15)	(16)

Based on this model I started to draw a concept map according to Novak and Cañas [2] to help students find their own learning route [3]. Fig. 1 depicts the sixteens dilemmas connected from the four domains.

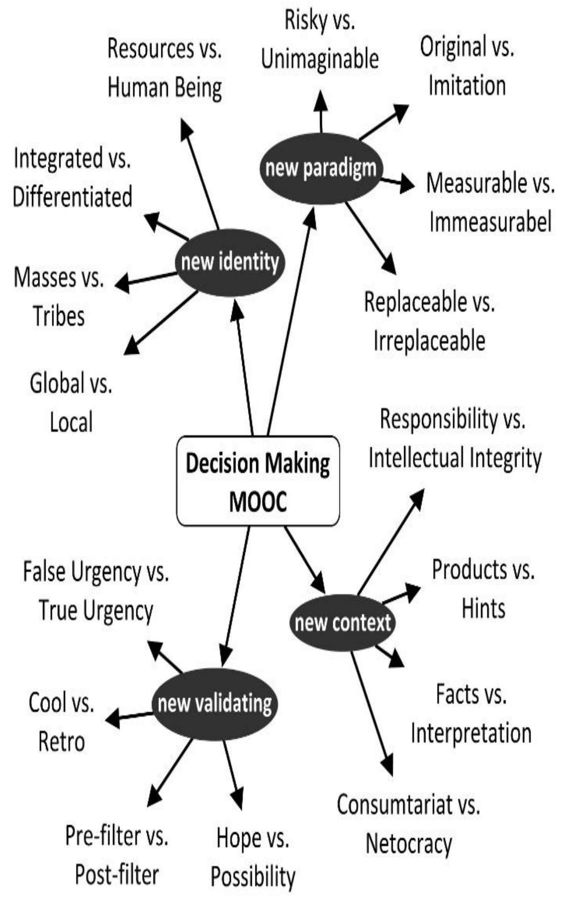

Figure 1: Sixteens dilemmas

III. CONNECT DECISION DILEMMAS TO CONFLICTS OF DRAMAS

Using dramas could help to depict decision situations as they over-emphasize the characters, making the conflict more obvious [4]. In the catharsis the decision makers realized: "this happened to me" or "this could have happened to me" or "this can happen to me tomorrow". So I decided to use dramas as means for getting the decision makers think about the conflict situations they face. Any decision makers have experience with a few such conflict situations and recognize them at once. The others they have not come across yet but some other decision makers are nodding that these are the ones they faced – thus the trust is built. They may face any of the conflicts tomorrow.

The dramas from William Shakespeare, Samuel Beckett, Henrik Ibsen, Molière and SlawomirMrožek are engaging with similar conflict situations than the sixteen decision dilemmas.

Risky vs. Unimaginable and Original vs. Imitation dilemmas are presented by Henrik Ibsen's The Wild Duck. Measurable vs. Immeasurable and Replaceable vs. Irreplaceable dilemmas are presented by Henrik Ibsen's An Enemy of the People. These four dilemmas illustrate the problem of creating new paradigm. This problem can be interpreted by William Shakespeare's Othello. Fig. 2 depicts the connections dilemmas from (1) to (4) with dramas.

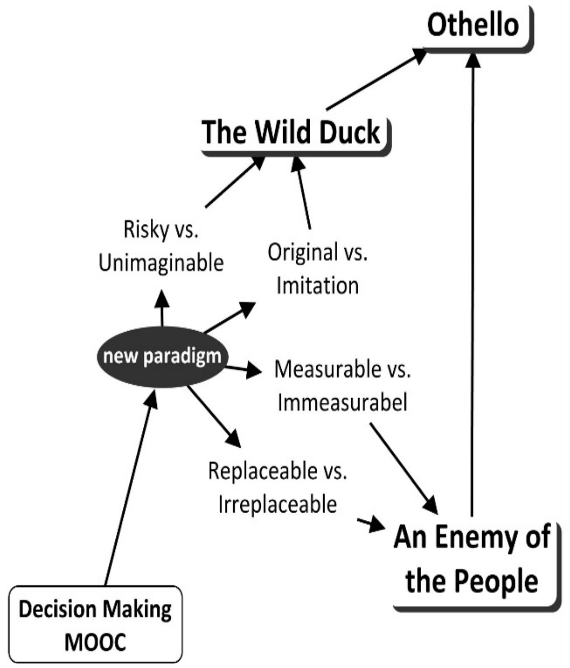

Figure 2: Dilemmas and dramas of new paradigm

Responsibility vs. Intellectual Integrity and Products vs. Hints dilemmas are presented by SlawomirMrožek's The Police. Facts vs. Interpretation and Consumtariat vs. Netocracy dilemmas are presented by Samuel Beckett's Waiting for Godot. These four dilemmas illustrate the problem of creating new context. This problem can be interpreted by William Shakespeare's Romeo and Juliet. Fig. 3 depicts the connections dilemmas of new context with dramas.

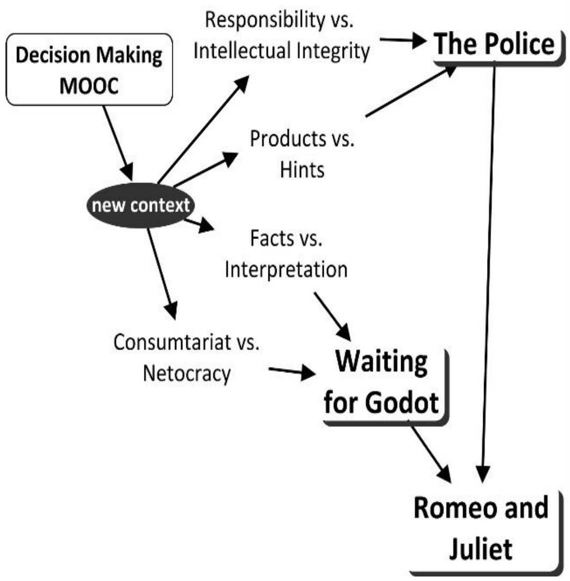

Figure 3: Dilemmas and dramas of new context

Hope vs. Possibility and Pre-filter vs. Post-filter dilemmas are presented by SlawomirMrožek's The Emigrants. Cool vs. Retro and False Urgency vs. True Urgency dilemmas are presented by

SlawomirMrožek's The Contract. These four dilemmas illustrate the problem of creating new validating. This problem can be interpreted by William Shakespeare's Macbeth. Fig. 4 depicts the connections dilemmas of new validating with dramas.

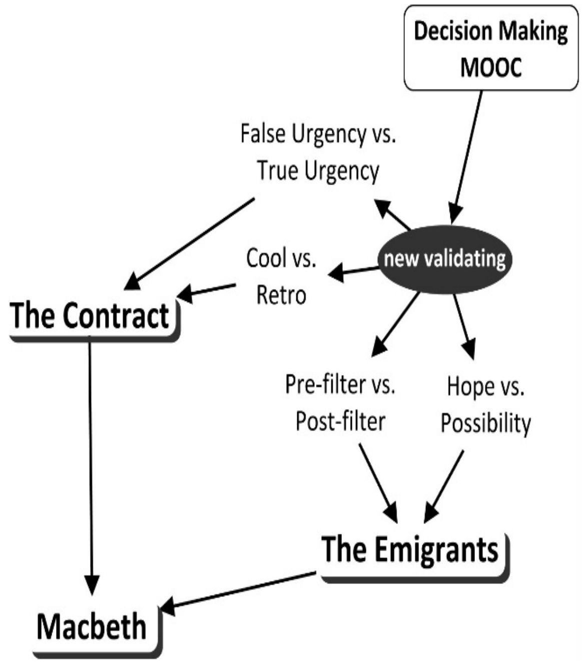

Figure 4: Dilemmas and dramas of new validating

Resource vs. Human Being and Integrated vs. Differentiated dilemmas are presented by Molière's The Misanthrope. Masses vs. Tribes and Global vs. Local dilemmas are presented by SlawomirMrožek's Tango. These four dilemmas illustrate the problem of creating new identity. This problem can be interpreted by William Shakespeare's Measure for Measure. Fig. 5 depicts the connections dilemmas of new identity with dramas.

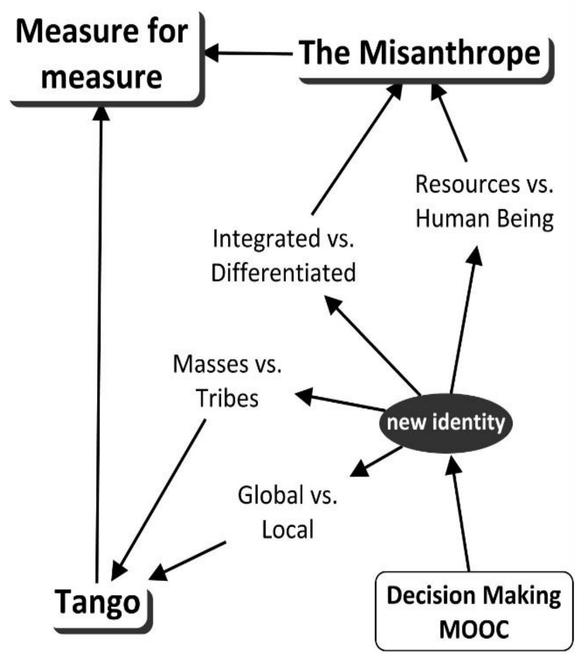

Figure 5: Dilemmas of dramas of new identity

IV. CONNECT DECISION DILEMMAS TO COMIC STRIPS

Comic strips [5] are perfect for displaying a few minutes of moving image sequences, in which most of the gags simple physical humour. They summoned the little world of burlesque or slapstick, in which the main character is looking for a way out of absurd situations.

"What does laughter mean?" Henri Bergson [6] began his work on Laughter with this simple and general question. His intention is to analyze the things that make us laugh in order to find out how it is that they make us laugh. According to dilemmas I wrote scenarios and based on these scenarios a graphic designer drew strips. Fig. 6 depicts the main actors of the scenarios.

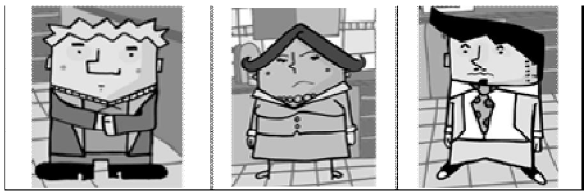

Figure 6: The main actors of Decision Making MOOC

CONCLUSION

Many have tried to describe the process of decision-making. No one has properly succeeded, so it is still up to humans to use the knowledge they need when they need it, then and there. One cannot make decisions based on the few steps described by decision algorithms. The thinking of a decision maker is an internal monologue whose building blocks are meaningful symbols. They are not comprised of data, nor do they operate according to the laws of mathematical logic. The thinking of decision makers cannot be codified and modelled [7]. There is no place for a tool that neglects or lacks the conviction and intention of a decision maker. So developing this course I focused decision-takers as human being whom decision making is an unending pathfinding quest. The conflicts of dramas and the comic strips could help to accept this unending pathfinding quest.

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A STUDY ON DEMOGRAPHIC AND MARKETING FACTORS INFLUENCING CONSUMERS TO CONSUME HOT POTS IN YANGON, MYANMAR

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Abstract— The objectives of the study were to identify the demographic and marketing factors influencing by analyzing and studying the importance level of demographic and marketing factorsinfluencing the decisions of consumers and provided the concluded recommendations to the investors wishing to invest in the hot pot restaurants in Yangon, Myanmar.
It is a quantitative study focusing on the analysis of factors influencing the decisions of consumers from the areas of demography of the consumers and the marketing factors in use and addresses the problem of the research. In this study, 400 consumers are participated in the target area among the population of 5.21 million (UNdata, 2015) in Yangon, Myanmar.
A multiple sampling method was used to obtain the participants for this study. The researcher also tested the reliability test in order to consistence of the survey and observation, or other measurable devices. A questionnaire was used in the study as the research instrument. The data collecting survey was developed after completing a literature review and this data was analyzed using the Data Analysis Program.
The results determined that demographic and marketing factors have a significant effect on influencing the consumers to consume Hot Pots in Yangon, Myanmar and suggest the future investors of hot pot restaurants ensure control not only over the quality of service but also over the product quality.

Keywords— Studying Demographic and Marketing Factors, Decision Making, Hot Pot, Consumer Behaviors.

I. INTRODUCTION

Hot pots are dishes in South East Asia. They utilize a variety of broths and consist of a simmering pot of stock at the center of the dining table. As the hot pot is kept simmering, ingredients are put into the pot and cooked on the table. Normally hot pot dishes include sliced meat, leaf vegetables, mushrooms, wontons, artificial meat, dumplings, egg, and seafood. The vegetables, fish, and meat must be fresh. There is a special dipping sauce provided for the hot pot meals, which is either spicy or sweet. Mostly hot pots are eaten in the winter season, especially for dinner.

Hot pots have been available in China for at least the last 1,000 years. The hot pot originates in Mongolia and Jurchen; at that time the main ingredient was meat commonly beef, mutton, and horse. They spread into southern China at the time of the Tang Dynasty and then continued their popularity into the Mongolia Yuan Dynasty. In time, the recipe developed regional varieties with different ingredients, such as seafood. By the Qing Dynasty (AD 1644 to 1912), hot pots became popular throughout most of China. Nowadays, in many modern homes and especially in the big cities, the traditional coal stove steamboat or hot pot has been replaced by electric, propane, butane gas, or induction cooker versions. The styles of hot pots have changed so much from region to region that now many different ingredients are used (Hot Pot Wikipedia, 2015).

There are many types of broths: normal, sweet and spiced broth. In the broth, many varieties of meat or vegetables can be added, including chicken, pork, beef, prawns, and other kinds of seafood. Pork, chicken, and beef are frozen and sliced thinly for the consumer when ordering. These thinly sliced meats are a bit more expensive than the normal cut, which is called special sliced meat. The pot is often sunk into the table and fueled by propane gas or electricity. Recently, most restaurants started using electronic cookers instead of gas because gas and propane are very dangerous and can easily explode and in addition cost more than cookers. Inside the hot cooking broth, meat or vegetables are loaded with chopsticks and cooking time can be only one to ten minutes depending on the type of food. Meat should be cooked for at least 15 minutes depending on its thickness. Other ingredients include leafy vegetables, mushrooms, seafood, and noodles, which do not take as much time to cook.

Yangon has three seasons: summer, rainy, and winter; winter sees the most hot pot orders. The most popular broth is the Chinese style with a spicy taste. The business of hot pots is rapidly growing as they enjoy many customers and the taste is familiar to the Myanmar people. Although hot pot restaurants open in the morning, people are most likely to eat at nighttime. At night, they usually come with family or friends. Here are some hot pot restaurants in Yangon: Shwe Kaung, Coca Suki, Apple, XOXO, Khai Li and O-Shabu Premium Hot Pot.

II. DETAILS EXPERIMENTAL

2.1 Research Process

This study used quantitative marketing research techniques to explore the accuracy of the factors that influence on consumers consuming hot pots in Yangon, Myanmar. Quantitative research is the case of asking people in a specific area of how many people like to consume hot pot and asking their opinions in a structured way to produce hard facts and statistics to guide the researcher to valid conclusions. In order to get the reliable statistics results, it is important to survey people in fairly large numbers and to make sure they are a representativeness of the target market. The quantitative approach can be used to validate the hypotheses of the research study. Finally, the quantitative research model uses the questionnaires as a tool and the market research is necessary for developing strategies in decision making and for success business.

2.2 Hypotheses

H01: Demographic factors have an influence upon the decision of consumers to consume hot pots in Yangon, Myanmar.

H02: Marketing factors have an influence upon the decision of the consumer to consume hot pots in Yangon, Myanmar.

2.3 Data Analysis

After collecting the questionnaires, the examination of data collected was coded with statistical software. All the data from the questionnaires were placed into the Statistical Software called SPSS, which stands for Data Analysis Program, and then confirmed. The research was determined through the Data Analysis Program and analyzed the data from the research through the descriptive statistics, which are Rating Scale and Mean, Standard Deviation, T-test, Multiple Regression and finally ANOVA (F -test).

2.4 Instruments

The validity and reliability tests are very important parts of measuring the device by using it as part of the data collection process. For the validity test, by calculating the internal consistency (IC) and for reliability test, Cronbach's Alpha is used to test the relationship between each independent and the dependent variables. For the rating scale, the researcher used the Likert scale, which is generally utilized in research that employs questionnaires.

2.5 Purposes

1. To identify the demographic and marketing factors influencing the decisions of consumers to consume hot pots in Yangon, Myanmar.
2. To analyze and study the importance level of demographic and marketing factors influencing the decisions of consumers to consume hot pots in Yangon, Myanmar.
3. To provide concluded recommendations to the investors wishing to invest in the hot pot restaurants in Yangon, Myanmar.

Table 1: Mean, Standard Deviation (SD), and Interpreting of consumers' decision to consume hot pots in Yangon, Myanmar

Descriptive Statistics	Means	SD	Interpreting
Age	2.66	0.697	17-27years old
Gender	1.52	0.500	Female
Income Level	2.79	1.012	Over 700,000 Kyats
Marital Status	1.33	0.500	Single
The meats are fresh	4.93	0.251	Strongly Agree
The restaurant offers a special discount for students	4.87	0.342	Strongly Agree
The restaurant is located in downtown area	4.70	0.462	Strongly Agree
The restaurant has convenient parking lots	4.80	0.442	Strongly Agree
The restaurant gives monthly promotion for everyone	4.92	0.272	Strongly Agree
Employees give good service to the customers	4.92	0.275	Strongly Agree
The restaurant supports fast service to the customers	4.93	0.251	Strongly Agree
The restaurant area is clean	4.88	0.322	Strongly Agree
The restaurant has a nice interior decoration	4.86	0.345	Strongly Agree
The restaurant provides good hospitality to the customers	4.86	0.345	Strongly Agree
The broth taste is important for you	4.88	0.328	Strongly Agree

III. RESULTS & DISCUSSION

3.1 The results of this research

gives to identify the demographic and marketing factors influencing the decisions of consumers to consume hot pots. At the same time, try to analyze and study the importance level of demographic and marketing factors influencing the decisions and conclude the recommendations to the investors wishing to invest in the hot pot restaurants in Yangon, Myanmar. On the other hand, the hypothesis finds out to use the data of demographic and 7Ps to be tested in the research of how many consumers' decision to consume hot pot in Yangon, Myanmar. As the study of the research done in Yangon, Myanmar on who and how as well as how many consumers are influenced by any factors to decide to consume hot pots by focusing on the analysis of factors influencing the decisions of consumers from the areas of demography of the consumers and the marketing factors in use.

Another benefit to this research is that it can be used as a basic guideline for developing other kinds of Food & Beverages instead of opening hot pot. As Myanmar has natural resources and plantation, the prices on food and vegetables will be cheaper in order to give fewer prices compared to the other countries. This research can not only give the information for the future investors who are willing to open a new hot pot restaurant in Yangon but also provide the information of coming up researcher which can also be concentrated on other methods base on the research.

3.2 Discussion

Based upon the research, the researcher is able to study the data using descriptive statistics. It not only provides a summary of the sample and the measurement by simplifying, but also organizes the incomplex graphic dissolution by configuring the basis of each set of quantitative analysis data. They are also commonly distinguished from the inferential statistics. By using these statistics, it is easy to understand what the data have shown. In a description of the demographics, most respondents were between 17 and 27 years old with their respondent percentage at 47% followed by female gender, which was 52% out of 100. However the level of income over 700,000 Kyats of 31% was the highest respondent accepted by the researchers. At the same time, those with household members from three to six people responded 67% while those with a marital status as single was 69%. Above all these descriptions show the highest percentage compared to the others. The researcher also receives the highest percentage of 'Yes' with 99% on the variables influencing each other. However, the other respondents of the marketing mix showed variables with regard to the 7 Ps, which are product, price, place, promotion, people, process, and physical evidence, with the last also getting the highest percentage of strongly agree compare to the others' scales.

CONCLUSIONS

The three objectives of this study were to identify the demographic and marketing factors influencing the decisions of consumers to consume hot pots in Yangon, Myanmar; to analyze and study the importance level of demographic and marketing factors influencing the decisions of consumers to consume hot pots in Yangon, Myanmar; and to provide recommendations to investors wishing to invest in hot pot restaurants in Yangon, Myanmar.

The study concentrates on consumers consuming hot pots in Yangon and is not generalized to other business fields. As the research was conducted during a specific time of period, it cannot be generalized for all time. The results from this study can guide and help in building a successful organization. On the other hand, the conceptual framework is designed based on research of that topic and includes dependent and independent variables. Therefore, the hypotheses have also been tested.

There are also many variables that involve making meaningful predictions. Dependent variables refers to what will be measured that will be affected during the research. One of the important variables of consumers' decision making is age because it can help to better understand how to maintain consumers' satisfaction and high quality across the lifespan. Despite it, it's good to know how to develop a better way of serving existing consumers; because of research on ageing, consumers decision making have been nearly bound to it.

Hot pot is consumed mostly in Asia in its various styles. In China, most of the people like their hot pots spicy but other countries offer different tastes including hot and spicy, tom yum, chicken broth and so on. In Yangon, people especially like to eat hot pots in the winter season since Yangon has three seasons of summer, rainy, and winter.

Researcher asked individual groups of people the standardized questions, following up with questions or exploring the topics that arose to better understanding the participants. The data was collected from hot pot consumers in Yangon, Myanmar. As the researcher produced 400 sets of questionnaires, the questions were asked about independent variables and factors that influenced the dependent variables.

In conclusion, the results from the research finding, researcher highly recommends that there must be highly opportunities to get profit from opening a new hot pot restaurant in Yangon. The consequences of the hypotheses results on demographics are accepted except for marital status. Multiple regression is used as to conjecture the dependent variable from the assessment of two or more independent variables.The results of the table show the multiple regression analysis influencing promotion factors of consumers to purchase hot pots in Yangon, Myanmar. Result found a Correlation of coefficient (r), and Adjusted R Square (R^2) to explain the price factor of consuming hot pot in Yangon, Myanmar. On the other hand, F-statistics, Sig. = 0.000 < 0.05, was significant at the 0.05 level. Durbin-Watson also found out that greater than 1.5 has no Auto correction between variables except "Place" factor.

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EVALUATION OF UNDERWRITER'S MUNICIPAL BOND PURCASE PROPOSAL (PREDETRMINATION OF THE PROCEEDINGS IN THE CASE OF EVENTUAL NEGOTIATED SALE OF MUNICIPAL BONDS IN THE CITY OF SHTIP)

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Abstract— There is some degree of misperception concerning the superiority of the competitive sale as the evidence suggests that large portion of municipal emissions take the form of negotiated purchase. The following article describes the procedure for negotiation of the eventual bond emissions in municipality of Shtip, Republic of Macedonia. The aim is to predetermine the most cost-effective method for evaluation of underwriter's municipal bond purchase proposal due to the substantial inexperience and deficit of expertise of the city's internal services. The literature offers various measures available to compare the relative costs of bond financing proposals. While net interest cost and net-present value are considered improper, it is thought that the best reliance for the purpose comes from the true interest cost method. The procedure incorporates calculation of true interest cost and duration of the underwriter's proposal and matching them with those for a sample group of similar bonds. In this particular case, as there are no other municipals to compare with, that would be the only available bond market index of the Macedonian Stock Exchange named OMB, with a portfolio completely made of long-term government securities.

Keywords— Municipal Bonds, Duration, Total Interest Cost, Negotiated Sale, Competitive Sale, Municipality of Shtip, Republic of Macedonia.

I. INTRODUCTION

The city of Shtip is already being established as the leading regional administrative, business and educational center in eastern Macedonia. The growth and expansion of the local and the regional economy have put pressure to the local government to secure additional financial resources to support the town's dynamic growth. Although a complete novelty, one of the options that's been seriously discussed recently, was the eventual municipal bond issues. For that reason, the Faculty of Economics offered a free consultation to the local authorities as part of the University's obligation for project participation, and ultimately a project was born. The ongoing project named "Municipal bonds as an alternative source of funding and effective management of collected funds for local economic development with special reference to Municipality of Stip", was meant as a certain guiding frame to sustain an effective decision making process for the local government if eventually a municipals issues were realized. Within the same project, two articles were already published covering different aspects of the same thematic, as for this one elaborates the procedure for negotiation of the eventual bond emissions. The aim is to resolve in advance the most cost-effective proceedings for evaluation of underwriter's municipal bond offerings. Here, we must notice that the results and the conclusion does not guarantee definite realization, and more likely, the article has the role of a "preparation tool". Yet, the ultimate decision concerning the municipal bonds emissions is left for the authorities.

II. NEGOTIATED VS COMPETITIVE SALE

Usually, there are two known marketing strategies available for the municipal bond issuers: the competitive, i.e., public sale, or a negotiated, i.e., private sale. A competitive bond sale requires bid solicitation from potential buyers, which are often the underwriters. The key feature of a competitive sale is that the principal redemption schedule, the coupon interest rates, and the structure of the bond issue are determined prior to the solicitation of competitive bids by the issuer [1]. Actually, this strategy resembles to a classical public auction where the bonds are sold to the buyer that is willing to pay the highest price, ensuring this way the lowest financing costs of the emission. It is very common during a competitive sale, the issuer to engage a financial expert and receive a professional assistance that includes evaluation of the bidding proposals and recommendation of the amount and structure of the emission. The advisor provides administrative and technical services as well such as the preparation of the official statements and even execution of the sales on the financial market. If we assemble the previous, the biggest advantage of competitive sale marketing strategy is the possibility to generate the lowest possible cost for the issuer due to underwriter's biding to investors that offer the highest paying price. This enables elimination of the inappropriateness of the selection process, thus ensuring higher level of fairness. However, since there could be a lack of information about the bidder's financial condition, and there is no insurance if they'll be successful in the future, a risk premium may be introduced to the bidding price, resulting in decline on bidder's (underwriter's) long-term gross profit margin.

In a negotiated, private sale strategy, the underwriter is firstly selected, usually through the solicitation of competitive requests for proposals [2]. The biggest difference from the competitive sale is that in a private sale, all the terms from the bond issue are negotiated previously, between the issuer and the potential underwriter. This means that the terms such as the interest cost, the redemption schedule, the structure of bond issue including the underwriter compensation, are subject of discussion between the both parties, before the realization of the sale. The selection of the potential underwriter does not implicitly guarantee realization of the emission if the negotiation is unsuccessful. The advantages of this strategy is that the underwriter conducts most of the administrative tasks, thus avoiding the need for engagement of the financial advisor as a third party. This will decrease the floatation costs and the overall expense involved in selling the new securities. In addition, the underwriter often performs pre-sale marketing activities, including making contacts with other potential underwriters, thereby increasing the chance of trading the bonds with the highest possible price. Another preference is the flexibility to changes concerning the terms of sale especially the structure and the date of the issue. The major disadvantage of the negotiated sale is the absence of direct competition between the potential underwriters. Yet, this limitation could be relative since the underwriter selection in most of the cases is based on a previous business or personal relationship with the issuer.

There is no clear empirical evidence about the cost-effectiveness supremacy neither of the competitive nor the negotiated sale strategy and the first impressions from the literature reviews are rather mixed. For example, Simonsen and Robins detected a positive relationship between the competitive sale and the lower interest cost in their research during the 90-ies [3]. On the other side, Leonard investigated that negotiated bond offering that rely on more aggressive marketing strategies could indeed generate higher investment demand and lower interest cost [4]. In addition, based on the research on a large sample study, the same author confirms that there isn't any hard evidence that would indicate that financing costs on private sale differ from the costs on competitive sale. A similar conclusion comes from Stevens and Wood. Accordingly, neither of the both methods had primacy considering the criteria to generate the lowest total interest cost [5]. All of these empirical studies, reveal to some extent the strengths and weaknesses of the alternative sale methods, as well as their mutual relationship. And as there is continuous dispute for the most cost-effective methodological approach, the negotiated sale approach has stepped forward in front of the public sale method. In 1970, 83 percent of the municipals issues were sold competitively, and only 17 percent sold by negotiation. By 1994 approximately 80 percent of municipal bonds were sold by negotiation, and only about 20 percent were sold by competitive offerings [6]. Referring to the last, Leonard adds that the trend of increased utilization of the former method is consistent with the real image of the corporate bond market where large portion of bond sales are completed by negotiation [7]. In general, negotiated sale may not be a single strategy. More likely, it represents a range of private sale strategies distinguished on the basis of competitiveness of the underwriter's selection process [8]. This indicates that some negotiated sales may be equally competitive as the so-called competitive sales [9].

Having in consideration the advantages and disadvantages of the both alternative methods of sale, there are some practical recommendations to follow in which situation and when exactly to rely on them. According to the Government Finance Officers Association of the United States and Canada, a competitive sale is appropriate when: issuer has a strong underlying credit rating at least in the "A" category; there's a case of emission of general obligation bonds or full faith obligations (e.g. alternate revenue bonds or debt certificates); structure of bond issue does not include special features that would require extensive explanation to the market; and, issue size is conducive to attracting investors. On the other side, a negotiated sale is more appropriate when: issuer has a credit rating lower than "A"; bond insurance is unavailable, debt structure is complicated; issuer wants input in how bonds are allocated among underwriting firms; and, issuer wants to target retail investors [10].

III. THE PROPOSED PROCEDURE

In the following lines we present the proposed procedure during the negotiation process of eventual bond issues shortly, according to Glen Stevens [11]. The intention is to evaluate a potential underwriter municipal bond purchase proposal in the terms of cost efficiency.

Step no. 1. ***Computing the duration and total interest cost – TIC of the purchase proposal.*** On the day a negotiated bond offering is approved and the purchase proposal is announced from the potential underwriter, the first step that should be done by the issuer of municipal bonds is calculation of duration and TIC of the received purchase proposal. The concept of duration has twofold meaning in the context of bonds. The first one relates to a measurement of how long, in years, it takes for the price of a bond to be repaid by its internal cash flows. In order to express the duration in reference with this meaning, we may use the so-called Macaulay duration, which is the most common measurement of duration of bonds and the only form of duration quoted in years. Developed in 1938 by Frederic Macaulay, it measures the number of years required to recover the true cost of a bond, considering the present value of all coupon and principal payments received in the future [12]:

$$Macaulay \quad Duration = \frac{\sum_{t=1}^{n} \frac{t \times C}{(1+i)^t} + \frac{n \times M}{(1+i)^n}}{P} \tag{1}$$

where n = number of cash flows, t = time to maturity, C = cash flow, i = required yield to return (discount rate), M = (serial) maturity par value, P = internal bond price.

Duration is an important measure for investors to consider, as bonds with higher durations carry more risk and have higher price volatility than bonds with lower durations. That's why the other significance of duration is the one as a measure of interest rate risk in bond investing. In general, the sensitivity of a bond's value to changing interest rates depends on both the length of time to maturity and on the pattern of cash flows provided by the bond [13]. To take care for this purpose, we can use the Modified duration which is an expanded (modified) version of the Macaulay duration. It reflects the percentage change in a price of bond for a 100 basis point change in interest rates by including the frequency of coupon payments [14].

$$Modified \quad Duration = \left[\frac{Macaulay \quad Duration}{\left(1 + \frac{ytm}{n}\right)} \right] \tag{1}$$

where n = number of coupon periods per year and ytn = yield to maturity.

As we can see, there is a connection between the Macaulay duration and modified duration. But despite the close relationship among them, we must have in mind that they are actually conceptually distinct. While Macaulay duration represents the average time until repayment expressed in units of time, for example years, the modified duration envelops the price sensitivity of a bond when its price is treated as a function of yield.

The previous measurements assume that the expected (the projected) cash flows will stay constant even if the interest rates change during time, which is the case of option-free bond instruments. For the ones with embedded options for example as the callable bonds, the Modified duration will not represent an adequate approximation of the movement of price. To determine the price of such bonds, it's necessary to apply the option pricing approach (option-adjusted spreads method). More accurate approximation to this is the effective duration, which is considered as a discrete approximation to the slope of the bond's value as a function of the interest rate [15]:

$$Effective \quad Duration = \frac{V2 - V3}{2 \times V1 \times \Delta y} \tag{3}$$

where V1 = initial price of the bond, V2 = price of the bond if yields decline by Δy, V3 = price of the bond if yields rise by Δy and Δy = percentage change in yield expressed in decimal.

Another important issue during the first step is the calculation of the overall financing costs. Calculating the financing costs of a municipal bond issue is not an easy task at all for several reasons: first, most municipal bond are issued with serial maturities which means that a portion of the principal payment is redeemed in each period during the life of a bond; second, much of the municipals are sold with premiums or discounts (for example if the offered coupon rate at the moment of the sale is lower than the established market interest rate, resulting in original issue discount), and third, it is very common that these bonds carry different serial coupon rates, making the calculation even more complex [16]. Many methodologies help determine the borrowing cost of bond issue, but only one is found to perform satisfactory for the purpose and that is the True Interest Cost method (TIC). Its strengths mitigate the weaknesses of alternative methods: unlike the Net Interest Cost, it incorporates time value of money; on the contrary of Net Present Value it yields an internal rate of return surpassing the problem with the choice of discount rate. It is defined as the interest (internal) rate necessary to equalize the present values of the issuer's future cash payments, i.e., principal and interest payments (including the accrued interest), with the net proceeds of the bond issue. [17]. The target value for the present value calculation of TIC is the net proceeds constructed as par value adjusted for any premiums or discounts, credit insurance and underwriter's discount. The target value for calculation of the more strict All-in-TIC measure, includes the cost of issuance expense above the rest [18]. Table 1 illustrates the calculation of net proceeds for TIC and All-in-TIC measure and Table 2 gives further insight of the expense components included in borrower's cost of issuance and underwriter's discount expense.

Table 1. Net proceeds elements for TIC and All-in-TIC measure

Net Proceeds Elements for TIC:	Net Proceeds Elements for All-in-TIC:
Par Value +/- Premium/Discount - Bond (Credit) Insurance - Underwriter's Discount	Par Value +/- Premium/Discount - Bond (Credit) Insurance - Underwriter's Discount - Cost of Issuance Expense
= *Net Proceeds*	= *Net Proceeds*

Source: Taylor, P., Koch, M. (2008). Introduction to Bond Math: Presentation to CDIAC. California Debt and Investment Advisory Commission – CDIAC, Barclays Capital, p. 40.

Table 2. Issuance expenses elements

Borrower's Costs of Issuance	Underwriters' Discount
Rating agency fees Issuer/ Authority fee Bond counsel fee Borrower's counsel fee Trustee fees Auditor's fee Printing and mailing costs Miscellaneous and contingency	Takedown Management fee Underwriters' counsel DTC CUSIP BMA assessment Dalcomp Electronic order entry Dalcomp wire charge Cal PSA CDIAC Day loan Out-of-pocket and closing costs Verification agent (if refunding)

Source: Taylor, P., Koch, M. (2008). Introduction to Bond Math: Presentation to CDIAC. California Debt and Investment Advisory Commission – CDIAC, Barclays Capital, p. 30.

If for example, the underwriter's proposal has par value of 2.000.000 euros, expected life of 10 years, with serial redemption of 200.000 euros for each year starting from 01.01.2018 until 01.01.2027, delivery date on 15.11.2016 and variable coupon rate, then the internal cash flows from the proposed municipal bond issue are presented as follows in the Appendix in Table 3. (bond insurance cost, underwriter's discount and cost of issuance are assumed at 2,5%, 3,0% and 2,0% from nominal value subsequently).

Step no. 2. ***Computing the duration and TIC of a cohort group of bonds, a sample of similar bonds marketed recently.*** It is very important to gather information and accomplish the same calculations for the key variables from the most closely related securities in the market for comparison purposes. Usually those refer to the municipal bonds issued by public authorities within the same branch (for example water management authorities, school districts, local government authorities etc.) with similar principal amounts, maturities and credit ratings. This practice is very common to the advanced countries with developed, very organized, structured and massive financial markets (large part of the municipal bonds issued in the US are listed on the specialized Bond Buyers Index, the so-called BBI) In our case, due to the poorly developed market without any registered municipal bonds issues, the choice is justifiably limited only to the securities that participate in the Macedonian index of listed bonds, the so-called OMB index (originally: ОМБ – Индекс на обврзници на Македонската Берза). The OMB index represents a consistent reference pricing measure defined as weighted average price of the official Macedonian long-term bond portfolio consisted from the central government's denationalization bonds. There are in total 10 separate issues included in the OMB index starting from the sixth to the fifteenth denationalization bond emission. The basic futures of the individual bond issues are shown in the Appendix in Table 4. The results of the performed calculations (price, discount, accrued interest, Macaulay duration, modified duration, effective duration, net proceeds and All-in-TIC) are presented also in the Appendix in Table 5.

Before we proceed any further, we have to consider some relevant notes for the following elements of calculation. First, all bond issues have expected average life of 10 years and equal coupon rates of 2%. The government of the RM retains the right to recall the bonds from the investors if the market conditions are not favorable. The rate of redemption of the par value is determined at 10% for each year according to the defined time schedule. The yield to maturity (ytm), or the required rate of return which is defined as the opportunity cost of the alternative investment, and plays the role of discount rate, is actually the government's long-term securities market interest rate. The price is the internal price of assumed 100€ face value of a security's expected cash streams during its life. The Macaulay duration is derived according to (1), while the modified and the effective duration are computed according to (2) and (3). Bond's discount is defined as negative difference between its par value and price at the moment of issue and is primarily determined between the relation of the coupon and the market interest rate (ytm). It is very obvious that during the period of the financial crisis the long-term market interest rate was established at very high level, thus generating large discounts depreciating the net proceeds of the relevant bond issues. It is computed respectively as:

$$Discount = ParValue \times (1 - \frac{Price}{100}) \quad (4)$$

According to the definition, accrued interest is the interest on a bond that has accumulated since the principal investment, or since the previous coupon payment if there has been one already. In our case it occurs from the first transaction on the date of issue up until the first coupon payment, which means that it takes into account all the days from the settlement date:

$$Accrued \quad Interest = \frac{Par \quad Value \times Coupon \quad Rate}{100} \times \frac{Days \quad Until \quad First \quad Coupon}{360} \tag{5}$$

We calculated the net proceeds according to the more restrictive scheme for All-in-TIC measure from Table 1. It is assumed for every separate issue that bond insurance cost, underwriter's discount expense and the cost of issuance are established at 0,5%, 1%, and 0,8% from nominal value respectively. And finally, All-in-TIC measure is defined as the internal rate of return that adjusts the net proceeds and the internal cash flows of the bond to zero.

Step no. 3. *Running a regression model and constructing the "line of best fit".* We can utilize the assembled data for the Macaulay duration and the All-in-TIC measure in a simple regression model and derive the predicted TIC for the proposed bond purchase offering. The simple regression is constructed as:

$$Y = (\alpha) + (\beta) X \tag{6}$$

If we take the measure of ALL-in-TIC as dependent variable and the duration measure as independent variable, then the regresion will take the form:

$$All - in - TIC = (\alpha) + (\beta) Mac.Dur. \tag{7}$$

By pairing the representative variables, the regression yields the following result:

$$Predicted \quad (All - in - TIC) = (0{,}755507) + (-0{,}14122) Mac.Dur. \tag{8}$$

Step no. 4. *Comparing the predicted TIC with the one from the underwriter's proposal.* Based on the comparison, the issuer could implement an appropriate strategy during the process of negotiation [19]. For example, if the overall effective cost is significantly higher, the issuer should ask for reasonable arguments from the underwriter that would explain the difference. If the negotiator fails to provide hard evidence, the next step would be to bargain for higher price. If noting from the previous demands happens, then the choice of the issuer is restricted to the following tactics: to delay or cancel the forthcoming bond issue (if the issuer is in advanced position to negotiate or if the need for liquidity is not so urgent), or accept the higher costs of the underwriter's bond offering (this option is justified only if the need for money is pressing or the issuer's negotiating rang is inferior).

If we go back on our example, it is clear that All-in-TIC of the proposed issue from the underwriter is determined at 5,70% (Table 5 under reference Shtip). The predicted All-in-TIC of the examined representative group of bonds is calculated at 0,0535 or 5,35% [0,755507 + (-0,14122)x4,971]. Evidently, the proposed effective cost falls to the zone of rejection of the underwriter's proposal since the proposed TIC is higher than the predicted one. Obviously, this case would be an adequate criteria in the countries with advanced financial markets. But, in the case of Macedonia, without any history of municipal bond issues, we suggest more flexible approach in the application of the presented criteria. Namely, since all of the cohort group securities are made of long-term government bonds with higher class in terms of credit quality, it is useful to simply add a very small percentage point on the reference criteria in order to express objectively the lower credit quality of the forthcoming municipal bond issue. For example if we calculate with 0,5% risk margin as a precaution measure, the predicted TIC will become 5,85% (5,35+0,5), then the proposed effective cost will automatically slip into the acceptance zone and the underwriter's offer will be considered as favorable in the terms of cost efficiency.

However, a difference in the effective financing cost and the one that has been predicted could indeed indicate on the following problematic issues [20]. The first indication is concerned on the issuer's rating quality and the level of the credit risk associated with it. The credit quality of the issuer might not be satisfactory which may in turn cause the overall cost to rise due to the incorporated higher risk premiums. Next, there could be an increased level of competition of municipal bond offerings for sale. It is quite possible that the bond market is "saturated" at the critical moment with higher than common supply of similar bond emissions. And finally, if a significant divergence in price is detected, it could be result of inappropriate (unfavorable) price offer. The underwriter's fees and interest rates might be pre-calculated excessively high which will conclusively produce unreasonable price offer. That's why it is important to use the approach of predicted TIC: it improves the negotiating position of the issuer and enables him to question and confront the underwriter's bond purchase proposal.

CONCLUSIONS

This article presents the proceedings in the case of negotiation of eventual bond emissions in municipality of Shtip, Republic of Macedonia, and predefines the most cost-effective method for evaluation of underwriter's sale proposal for the same purpose. The proposed procedure is consisted from 4 basic steps: computing the duration and TIC of the purchase proposal; computing the duration and TIC of a cohort group of bonds; running a regression model and constructing the predicted TIC of the representative group of bonds; and comparing the predicted TIC with the one from the underwriter's proposal. These proceedings allow the issuer to apply an appropriate strategy during the process of negotiation and enable him to question and confront the underwriter's bond purchase proposal.

APPENDIX

Table 3. Internal cash flows of the proposed local government bond issue in municipality of Stip

Date	Interest basis	Interest rate	Interest	Redemption	Cash flow
01.01.2018	2.000.000	3,00%	67.500	200.000	267.500
01.01.2019	1.800.000	3,20%	57.600	200.000	257.600
01.01.2020	1.600.000	3,40%	54.400	200.000	254.400
01.01.2021	1.400.000	3,60%	50.400	200.000	250.400
01.01.2022	1.200.000	3,80%	45.600	200.000	245.600
01.01.2023	1.000.000	4,00%	40.000	200.000	240.000
01.01.2024	800.000	4,10%	32.800	200.000	232.800
01.01.2025	600.000	4,20%	25.200	200.000	225.200
01.01.2026	400.000	4,30%	17.200	200.000	217.200
01.01.2027	200.000	4,40%	8.800	200.000	208.800

Source: Author's calculations.

Table 4. Basic features of the individual bond issues listed on the OMB index

Issue No.	Par value (€)	Date of issue	Coupon (annual)	Options	Redemption dynamic (1/10 from par value)	Ytm
6-th	18.000.000	01.03.2007	2%	callable	01.06.2008-01.06.2017	11,8%
7-th	30.000.000	25.08.2008	2%	callable	01.06.2009-01.06.2018	11,8%
8-th	23.000.000	06.04.2009	2%	callable	01.06.2010-01.06.2019	11,6%
9-th	30.000.000	21.04.2010	2%	callable	01.06.2011-01.06.2020	8,6%
10-th	11.000.000	30.03.2011	2%	callable	01.06.2012-01.06.2021	6,2%
11-th	10.000.000	14.05.2012	2%	callable	01.06.2013-01.06.2022	6,2%
12-th	13.000.000	22.05.2013	2%	callable	01.06.2014-01.06.2023	5,3%
13-th	10.000.000	05.08.2014	2%	callable	01.06.2015-01.06.2024	5,0%
14-th	9.500.000	01.06.2015	2%	callable	01.06.2016-01.06.2025	3,5%
15-th	12.000.000	20.06.2016	2%	callable	01.06.2017-01.06.2019	3,7%
Shtip	2.000.000	15.11.2016	variable	callable	01.01.2018-01.01.2027	4,0%

Source: Macedonian Stock Exchange – Prospects of the individual bond emissions; Author's example.

Table 5. Price, discount, accrued interest, Macaulay duration, modified duration, effective duration, net proceeds and All-in-TIC for the cohort group and proposed bond issue

Issue No.	Price (100 €)	Premium /Discount	Accrued interest	Mac. dur.	Mod. dur.	Eff. dur.	Net proceeds	All-in-TIC
6-th	64,709	(6.352.380)	450.000	**4,437**	3,969	3,972	11.233.620	**12,72%**
7-th	63,839	(10.848.300)	458.333	**4,484**	4,011	4,014	18.461.700	**12,73%**
8-th	65,046	(8.039.420)	529.000	**4,460**	3,996	4,000	14.431.580	**12,51%**
9-th	73,586	(7.924.200)	665.000	**4,675**	4,305	4,309	21.385.800	**9,34%**
10-th	81,962	(1.984.180)	256.667	**4,847**	4,564	4,569	8.762.820	**6,83%**
11-th	81,731	(1.826.900)	208.889	**4,858**	4,574	4,579	7.943.100	**6,83%**
12-th	85,164	(1.928.680)	265.778	**4,928**	4,680	4,685	10.772.320	**5,89%**
13-th	85,986	(1.401.400)	163.889	**4,969**	4,732	4,738	8.368.600	**5,58%**
14-th	92,785	(685.425)	190.000	**5,070**	4,898	4,904	8.596.075	**4,02%**
15-th	91,776	(986.880)	226.667	**5,059**	4,878	4,884	10.737.120	**4,22%**
Shtip	98,112	(37.760)	67.500	**4,971**	4,780	4,785	1.888.240	**5,70%**

Source: Author's calculations.

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USING GRANULAR SULPHUR PROPERTIES TO MODIFY GRANULATION UNITS AT SOUTH PARS GAS COMPLEX

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Abstract— The purpose of this study is to modify the design of South Pars Gas Complex solidification and storage sulphur units regarding granular sulphur property. In the recent years the silo outlet was chocked frequently therefore the operator had to hit strongly the silo wall by a hammer or picked via outlet. Site observation shows that flow-ability is decreased with decreasing particle size and increasing Moisture content. In this investigation firstly by use of granular property silo design was verified based on EN1991-4. The result shown that the silo geometry was designed for mass-flow profile correctly. The property of stored granular sulphur by test specimens and unit mechanisms were checked during the site operation condition. The result of initial product specimens in every unit's start up, that stored in silo conical hopper, showed that product characteristics has deviation from vendor design documents. Investigation about these specification and their relation was determined that they are the most important physical-mechanical parameter of bulk granular that deviation of them will cause consolidation, reducing flow-ability factor of granules and finally chocking the silo outlet. The final outcome of this study is shown that the current granulation unit mechanism is not able to control the three main parameters size, moisture and "consolidation time". For elimination of these deviations, nonstop and accurate production, quality improving and reduce environmental pollution, three proposition to modify the current granulation units.

Keywords— Granular Properties, Sulphur, Silo, Moisture Content, South Pars Gas Complex.

I. INTRODUCTION

Liquid sulphur from the sulphur recovery unit is stored in a heated tank, from which it is sent to the sulphur solidification unit for conversion to solid sulphur granules using the Enersul (Procor) GX™ drum granulation process. The GX™ process functions by accretion: small granules build up layer by layer by repeated coating with liquid sulphur, followed by cooling to solidify the superficial layer of liquid sulphur, until the desired size range is reached [i]. Ultimately the sulphur granules are loaded onto trucks for export. phases two and three has two 210-tones, phase one has a 200 tons and another 400 tones silos for intermediate storage of the granular solid sulphur between the GX™ plant and the export truck loading facilities [ii]. There was a problem with conglomeration in the outlet of silo (no flow ability), which was causing difficulties during truck loading. The operator had to hit the silo with a hammer to get the sulphur granules flow-ability, which was not only risked damaging the silo body and the check valve but also hazardous for the operator.

Flow-ability is the ability of granular solids to flow, Flow-ability is a consequence of the combination of the physical properties of material that influence flow, environmental conditions, and the equipment used for handling, storing, and processing these materials, however there is no significant relationship for the trying to related flow-ability.

In the present investigation at the first step the problems was identified then based on granulation property the silo design was verified, for the second step the property of product which store in silo was checked by specimens in different operation condition amongst start up and unit shutdown. At the third step the mechanism of granulation unit was investigated and some modification was proposed.

II. IDENTIFIED PROBLEM IN GRANULATION AND SULPHUR STORAGE UNIT

2.1 ARCHING AND RAT-HOLING IN SILO

A stable arch forms above the silo outlet of phases2&3, inhibiting the flow of granular sulphur. The reason for this arching is compaction and consolidation of the granules with fine material formed when some of them crumble under the weight of the material in the silo.

When only the granular sulphur in the centre of the funnel section of the silo flows out and dead zones of static material line the walls of the funnel. The reason for this is the strength (unconfined yield strength) of the bulk solid. The longer that granular sulphur is stored in a static state, the more it consolidates and the greater the risk of rat-holing becomes. The silo is not completely emptied sufficiently often, the sulphur left inside becomes progressively more consolidated and Forms concretions on the inside of the conical section. To prevent that, operators have resorted to hitting the funnel section of the silo and the outlet check valve with hammers so as to dislodge any material adhering to their inside surfaces. But that practice causes damage, as "Figures 1 and 2" shows. Based on operation reports, all Phases (1, 2&3, 4&5 and 9&10) have the problem but phases 2&3 have the most problem in outlet clogging. In phases 9&10 silos have some rods which comes through nuzzles at the hopper wall to open the outlet, Figures 3.

Figure 1: Phases2&3 silo

Figure 2: Phases9&10 silo

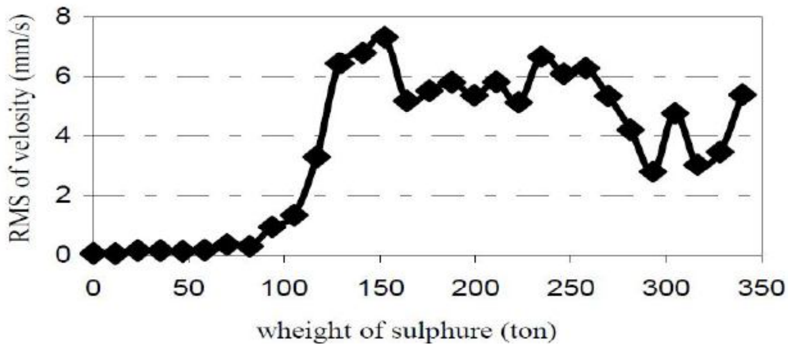

Figure 3: RMS of silo in phase1 VS silo content

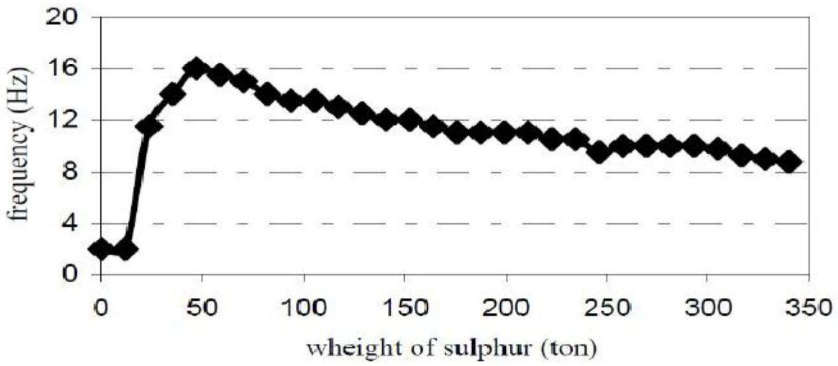

Figure 4: Frequency of silo in phase one VS silo content

2.2 SILO QUAKING AND HONKING

This problem is observed in phase one 400 tones storage silo; during silo unloading the structure has terrible quake and honking. Frequency and RMS of silo VS silo content is measured by VT60 shown in figures 4 and 5 [iii]. Now the operation cannot use the whole capacity of silo. Based on previous research by Roberts [iv] and Schulze [v] this problem is happen by accelerate of caking and not continues flow of bulk solids.

2.3 CONVEYER PROBLEMS

As it shown in figures 6 and 7, the conveyer of phases2&3 in compare of phase one has a limited space. Beside variety of products size distribution always the bigger products catch between conveyer edgings and the smaller are scattered in the unit area, so lots of environmental pollution will cause.

Figure 5: phase 1convier to silo

Figure 6: phase 2&3 conveyer to silo

III. SILO DESIGN VERIFICATION

By use of sulphur granulation properties, Silo design was checked based on EN1991-4 (Figure 8) the result shown that the angle could be extended to 38 degree, but the current is 30 degree and steeper, so it is an acceptable design for hopper. Friction coefficient as an internal angle between granular sulphur, also between granules and rigid wall of silo was used from Schulze's work for the same granulator drum [vi].

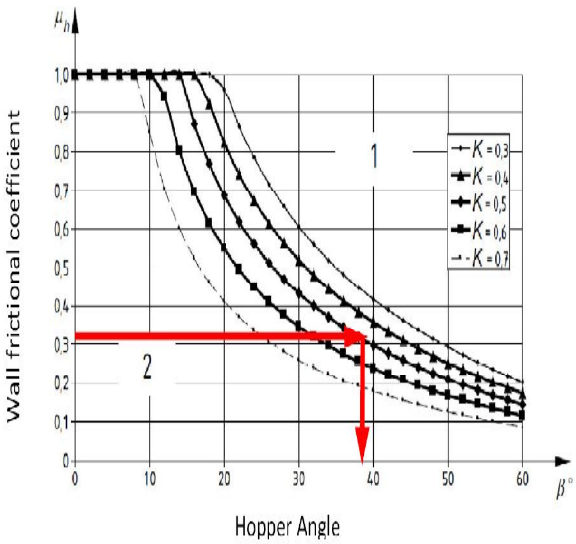

Figure 7: silo design angel verified

IV. STORED GRANULES PROPERTIES

At the unit's start up granular size and temperature are controlling manually by operator with sprayed water quantity in granulator but the temperature of liquid sulphur is not steady and depends on operation of Sulphur Recovery Unit (SRU). Based on site observations the properties of product in start up is different from the normal operation (figures 9, 10, 11).

As for the critical continuum pressure which granules can tolerate depends on size distribution, which affects critical breakage energy and bulk modulus. Off-size and misshapen granules decrease the entropy [vii]. Based on site observation flow ability and entropy is related to the granules size distribution and angle of response. So at the second step, the properties of stored sulphur granules in silos such as size distribution, friability and moisture content was checked by laboratory test.

Figure 8: Granulator at the start up

Figure 9: Normal product sample

Figure 10: start up sample product

4.1 TEST METHOD FOR SIZE DISTRIBUTION ANALYSIS [viii]

4.1.1 APPARATUS

- Sieves of the following mesh sizes (4.75 mm, 2.36 mm, 1.18 mm, 600 micron, 300 micron).
- Sieve shaker (Model EFL [MK1]).
- Balance, accurate to 0.1 g.
- Oven.

4.1.2 PROCEDURE

- The gross sample is collected as per Method S1-77.
- The sample of sulphur used for sieve analysis is thoroughly mixed and reduced by use of a sample splitter or by quartering to an amount suitable for testing. Reduction to an exact predetermined weight is not permitted(Fig. 2)
- The weight of the test sample is approximately 250 g.
- The sample is air dried to essentially constant weight followed by oven drying at 75 ± 5ºC to constant weight, i.e. until the loss in weight is not more than 0.1 g/4h.
- The sample is weighed accurately before screening to the nearest 0.1 g.
- The sieves are nested in order of decreasing mesh size from top to bottom and the sample is placed on the top sieve. The sieve shaker is turned on and the sample is screened for 3 minutes.
- The fraction remaining on each sieve is weighed to the nearest 0.1 g.

4.1.3 RESULTS ANALYSIS

The percentage of material retained on each sieve in relation to the total weight of the original sample is calculated as follows:

$$\% \text{ Retained} = \frac{A}{W} * 100 \qquad (1)$$

Where: A = weight of fraction retained on each sieve, grams.
W = total weight of the sample, grams

Figure 11: Sample quartering method

Figure 12: Shaker

4.2 FRIABILITY TEST [ix]

The friability of sulphur forms is determined using a 28-inch (700 mm) diameter tumbler test apparatus, based on ASTM C131-69.

4.2.1 Summary of method

Three laboratory-prepared samples are placed into the friability tumbler. The tumbler is rotated at a speed of 31 r/min for a total of 40 revolutions. The sample is removed, washed, and passed through a No. 50 (3,300-micron) sieve. The original dry sample weight minus the quantity of material retained on the sieve is calculated as a percentage of the original sample and is reported as the fines production. The degree of degradation is determined from the screen analysis on the pre-screened material prior to tumbling and after tumbling. A percentage increase in the fineness is defined as the Particle Breakdown Modulus (PBM).

4.2.2 Apparatus

Sulphur friability tumbler (fig. 3), balance, sieves, oven and container.

4.2.3 Sample

The samples are air-dried to essentially constant weight and pre-screened to remove the minus No. 16 material prior to friability testing. The quantity of plus No. 16 material for friability testing should be 500-600 g.

4.2.4 Test procedure

- Three tumblers are charged per friability test.
- The test samples are oven-dried at 50±5°C to constant weight, weighed to the nearest 0.1 g and air cooled.
- The sample is transferred into the tumbler and rotated at a speed of 31±1 r/min for a total of 40 revolutions.
- After the prescribed number of revolutions, the material is cleaned from the tumbler, weighed and recorded.

This procedure is repeated three times.

- The amount of residual material retained on the No. 50 sieve after washing is determined.
- The three samples of dried recovered material from above are combined.
- A dry sieve analysis is conducted on the combined material.
- A sieve analysis is carried out on a representative sample of the pre-screened material which was used for the friability test.

4.2.5 Calculation

Fines production: This is the difference between the original sample weight and the final retained weight after washing over the 300-µ sieve as a percentage of the original sample weight. The average value of three runs is reported.

A - Original sample weight

B - Weight of material retained on 300µ sieve following washing and drying

C - Weight of minus 300µ material

$$C = A - B \qquad \text{Fines production} = \frac{C}{A} * 100$$

Figure 13: the weight of tray 1.18

Figure 14: 28 inch (700mm) diameter tumbler

4.2.6 TEST RESULTS

The laboratory test results were subjected to statistical analysis to compare granule friability with particle size values. The x-axis is the size percentage of granules which are larger than 6 mm and the y-axis is the resultant friability. The results show a correlation in the measured range (Figures 16, 17). The sizes over SUDIC specification (6mm) will increase the rate of friability. In plain word bigger size has more tendency in friability.

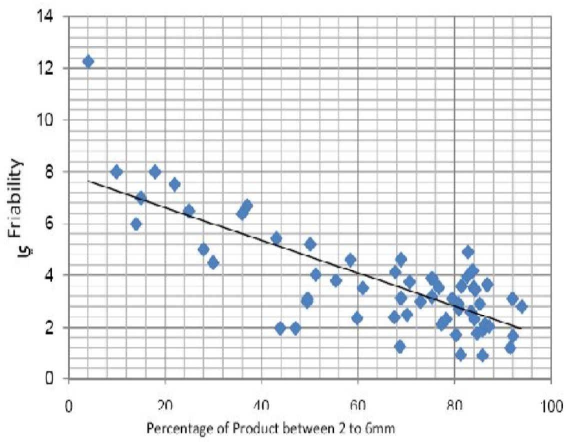

Figure 15: friability and Product between 2 to 6mm

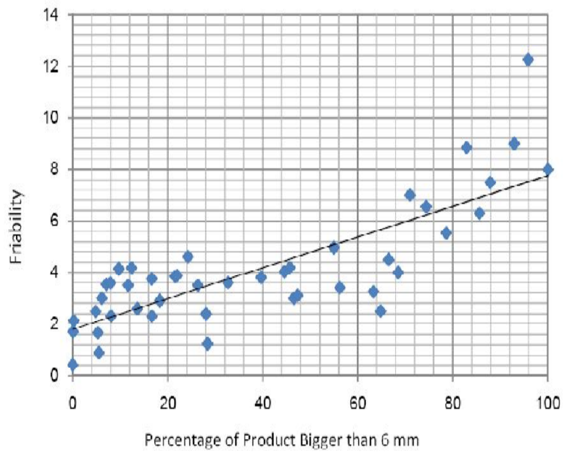

Figure 16: friability and Product Bigger than 6 mm

4.3 Moisture in sulphur by Karl Fischer[x]

These testes are done based Elf exploration product No9- (LURGI).

4.3.1 Apparatus

- Description: Automatic Karl Fisher Titrator,
- Manufacturer: Metrohm
- Model: 756 Karl Fisher

The Karl Fischer reagent should be checked daily to determine the factor in mg H2O/ml.

4.3.2 Reagents

- Pyridine
- Methanol
- Sulfur dioxide
- 2- methoxyethanol
- iodine

4.3.3 Test procedure

- 20- 25 gr of sulphur is weighed
- weighed sulphur is poured into the titrating bottle of Karl Fisher Apparatus
- Karl Fisher Apparatus is started by pushing the start button.

About 100ml methanol is poured into the titrating bottle of Karl Fisher apparatus, and then 20- 25gr of the pulverized sulphur is poured through a funnel into the titrating bottle and closed the titrating bottle. After a few minutes the water determination is carried out by the addition of Karl Fisher solution.

Note1: the amount of require sulphur is determined by weighing the weighing bottle before and after sulphur addition and taking the difference of the two weightings.

Note2: the factor of the Karl Fisher solution in mg H2O solution is determined daily.

V. DISCAUTION AND RECOMMENDED MODIFICATIONS

As it is observed in section 4, phases2&3's silos were designed correctly as per En 1991-4. So based on site observation and laboratory result some recommendation is proposed to modify the initial granules which store near the silo outlet.

5.1 INCREASING GRANULES DYNAMIC ENERGY

As it was mentioned in Schulze's investigation about "time consolidation" on "caking" [xi], for preventing time consolidation and improve sulphur granules dynamic energy a process air line was added at the phases2&3 silo's hopper wall at 22-Dec-2011, figure 18, After modification, there isn't any silo clogging reports till now; also in case of any clogging, the path will be opened with the high pressure process air. Also it is recommended to use this method for solving silo quacking in phase one.

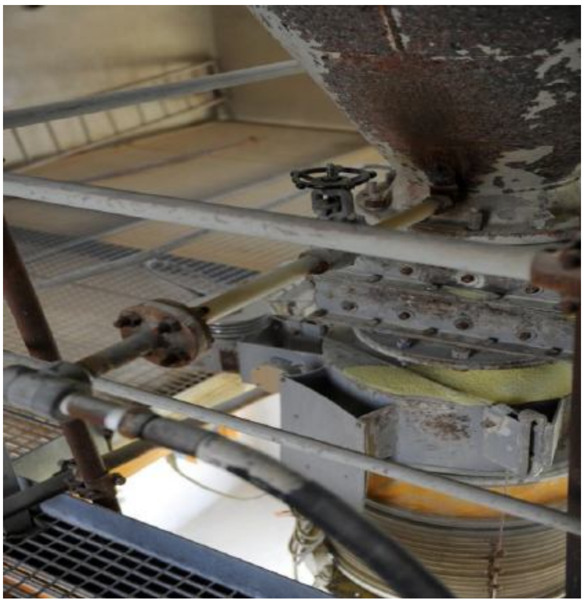

Figure 17: process air line to phases2&3 silos

5.2 SIZE MODIFICATION

Based on sieve analysis results and site observations, the initial products at unit's start up have different properties to the normal operation and have some conglomerations (figures 9, 10, 11). Also friability test result shown bigger sizes has more tendencies in friability.

So the only granular material with proper mechanical characteristics and moisture content should be stored in the silo. To achieve this purpose a further vibration screen should be provided to separate initial product at the unit's start up and recycle them to the re-melting pit, this mechanism will facilitate unit's start-up also, figure 19.

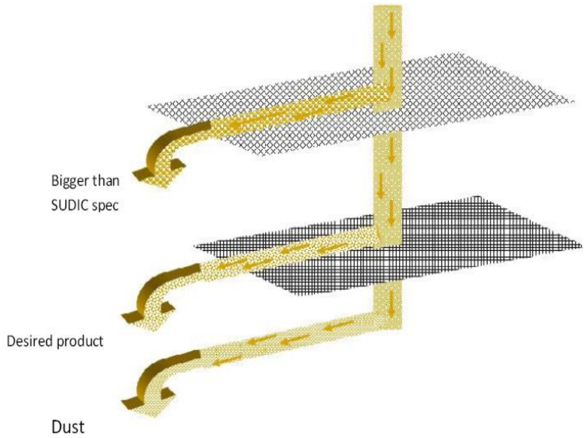

Figure 18: schematic Recommended screen

5.3 Drying, cooling And dust removing

All previous investigation shows that because of liquid bridge formation, increasing in moisture content (not too much water) decreases the entropy and flow ability, Based on Moisture analysis results and site observations in case of high water spray in GX drum, for example 9-feb-2010, the initial products at unit's start up have different properties to the normal operation, very small size, low flow-ability and sometimes chocking the GX drum outlet. As it was mentioned in section 3.1, phases2&3 granulation unit had the most problems with outlet clogging in spite of its better operation condition. Also by comparison with phases4&5, it has a process air line more than phases2&3 and less clogging. In phase1 the granule exposed to air during its long route (figure 6) and there is a fan at the top of silo to remove dust and vapour.

Moisture content intensifies the rate of decreasing flow-ability therefore increasing caking and clogging, to remove moisture content and dust from granular sulphur using process air is suggested, in case of medium silo it is recommended to use air drying in the hopper of silo like section 6.1, but in huge silo it better to remove moisture before entering the silo. This suggestion for Fluidized Bed Cooler schematic is shown in figure 20. It will also decrease the stored temperature (temperature has direct relation to caking).

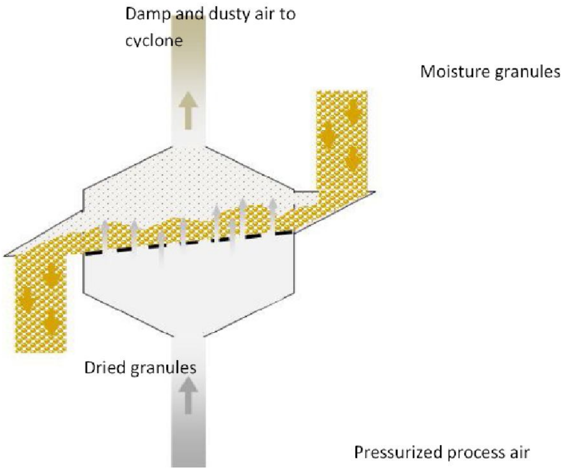

Figure 19: schematic recommended Fluidized Bed Cooler

5.4 BUCKET ELEVATOR

Bucket elevator is segested for units which has space limitation for conveyer, to prevent sulphur dust emision and site environmental polution, Buckets's material should be stanless steal, the experience in phases9&10's granulation unit shows disturtion and fracture in "antistatic Polyamid" Buckets due to temprature and granules weight.

ACKNOWLEDGMENTS

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EDUCATION ENGINEERING IN ENGINEERING EDUCATION (PROVIDING A CONCEPTUAL MODEL OF EDUCATION BASED ON THE EFQM MODEL IN IMIDRO)

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Abstract— The purpose of this paper is design and validation of a Training model in the Iranian Mines and Mining Industries Development and Renovation Organization. The study is an applied research in terms of the purpose and a descriptive (analytical) survey. The research population is consisted of all 150 managers and employees of Mines and Mining Industries Development and Renovation Organization. Considering the research population, 122 people were selected using stratified random sampling method. Library and field method have been used to collect the data. A researcher-made questionnaire has been used in this study by which the current and desirable situation of the establishment criteria of the Training and Development Excellence Model were evaluated and measured as the basic data for designing the model. SPSS and LISREL statistical software and the variety of inferential test were used in order to analyze the gathered information. The results showed that there is a significant difference between current and desired situation of the criteria of the Iranian Training and Development Excellence Model in IMIDRO and it led to provide desirable Training models in the organization. The designed model was then presented to the experts and professors for final validation.

Keywords— Excellence Model, Training and Development, conceptual model , adult training , design and validation.

I. INTRODUCTION

Human resources are the main asset of any organization or firm. This stems from the fact that all other assets can create value when they are ideally applied and used by trained and qualified human resources towards achieving organizational goals.
Human resource capabilities have an important role in the right and optimum use of resources; therefore, all organizations are looking to attract empowered workforce and increasing their capabilities. One of the effective ways to increase the employees' capabilities in an organization is providing necessary trainings towards achieving the organization goals and requirements.
Any organization, regardless of type, size, structure, maturity and amount of success in achieving its goals, needs to measure its success in achieving the training and development strategies and ideals.
Today, learning becomes a part of organizational culture. Organizations should change and adapt quickly focusing on learning (Kritsonis and smith, 2006: 6-1). In the current situation, the organization human resource training not only is useful but also has become inevitable for the growth and survival of the organization. Understanding this necessity and awareness of the benefits and strategic effects of human resource training is the first step towards quality orientation in the training programs.
The advancement of knowledge and environmental changes has caused that organizations face with methods, tasks, and new technologies. Keeping pace with this change is among the requirements of organizational growth and survival. In the same order in which the new duties and technologies appear, the organization members should be enabled to rapid acquisition of the related competencies, knowledge and skills (Walton, 1384: 10). Therefore, rapid technological change and radical environmental transformation make organizations more than ever committed and required to provide organizational training (Smith, 2007: 38-32). Proposing the Organizational University theory by the world successful managers can be found as a sign of growing importance of these trainings on improving the human resources knowledge and skills.
The Training and Development Excellence Model is the resultant of the need for design and developing a conceptual model and a common language with the aim of promoting the status and performance of educational management in Iranian organization. To achieve this, the excellence model is designed and developed in collaboration with university professors, key informers and industry experts. (Booklet of educational and Development excellence model, 2013).
The model is based on five fundamental principles that underpin the overall framework of the model. These principles provide the foundations of planning and deployment of systems and processes contained in Training and Development Excellence Model and are closely associated with the model criteria. These values include the strategic and investment vision, participation and development, learning culture, integrity and continuity, system interaction and focus on value-creating results (Booklet of Training and Development Excellence Model, 2013).
Training and Development Excellence Model is designed in three parts of enablers, processes and results. The model is consisted of 9 criteria and 27 sub-criteria and it will be evaluated based on the RADAR scoring logic and the score range 1000.

Training and Development Excellence Model criteria include training and development leadership, learning culture, training and development strategy, educational needs assessment, Training executive management, educational planning and design, processes assessment and monitoring, performance results, Organizational key results, empowerment, processes and results (Ibid.)

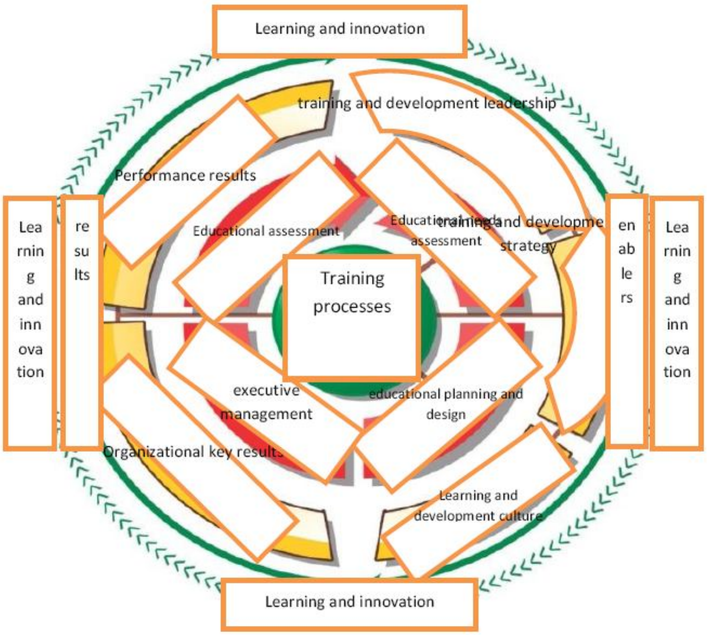

Figure 1: Training and Development Excellence Model

Design and validation of appropriate educational model based on the Iranian Training and Development Model is the main purpose of this research; this is an important step toward flourishing the human capital capabilities of the Iranian Mines and Mining Industries Development and Renovation Organization that due to the nature of its tasks, it is essential to use creativity and innovation of these capitals. Secondary objectives of the study include reviewing the status of educational excellence components, prioritizing these components, providing the ideal model and validation the desirable model.

II. RESEARCH METHODOLOGY

The present study is an applied research in terms of the purpose and it is considered as a descriptive (analytical) survey. The study population is consisted of all 150 managers and employees of the Iranian Mines and Mining Industries Development and Renovation Organization. 30 Managers and 120 employees comprise the research population. According to the study population, all managers and also 92 employees were selected by stratified random sampling method.

Table 1: Demographic Information

Total		Expert		Manager		Group Levels	Demographic characteristics
Percent	Frequency	Percent	Frequency	Percent	Frequency		
52 .1	63	44 .6	54	7 .4	9	*Bachelor*	*Education*
44 .6	*54*	*30 .6*	*37*	*14*	*17*	*Master*	
3.3	4	-	0	3.3	4	*Ph.D.*	
30 .3	36	27 .7	33	2 .5	3	*Female*	*Sex*
69 .7	83	47 .9	57	21 .8	26	*Male*	
28 .1	34	28 .1	34	-	0	*Less than 10 years*	*Job experience*
45 .5	55	35 .6	43	9.9	12	*11 to 20 years*	
16 .4	32	11 .6	14	14 .9	18	*More than 20 years*	
22 .2	26	22 .2	26	-	0	Single	*Marital status*
77 .8	91	52 .1	61	25 .6	30	Married	
11 .5	14	11 .5	14	-	0	*Less than 30 years*	*Work experience*
48 .8	59	38	46	10 .7	13	*31 to 40 years*	
39 .7	48	25 .6	31	14	17	*More than 41 years*	

In the present study, a 54-item questionnaire in ordinal scale was used to exploit the field study; the questionnaire measures the current and desirable status of Training and Development Excellence Model establishment criteria and the Cronbach's alpha is used for evaluating the questionnaire reliability. To validate the questionnaire, the opinions of 22 experts including university professors, experienced managers and experts of training and excellence was used; based on the comments received from them and deleting or correcting items a 54-item questionnaire was finally approved as the measuring tool.

12 items are related to the empowerments (items 1 to 12), 30 items are related to processes components (items 13 to 42) and 12 items are related to the results components (items 43 54). Accordingly, the appropriate number of questionnaires that are approved in terms of validity and reliability (alpha = 0.96) were analyzed after completion.

Using descriptive and inferential statistics, the collected information were analyzed by SPSS and LISREL software; in descriptive statistics, to describe the variables of Training and Development Excellence Model, mode, median and mean were measured as measures of central tendency; variation range, variance and standard deviation were measured as indicators of dispersion and standard error, coefficient of deviation and coefficient of elongation were measured as distribution indicators; In descriptive statistics, the statistical models of paired samples t-test (to determine criteria of Training and Development of Excellence Model in current and desired status), independent sample t-test (to study the criteria of Training and Development of Excellence Model emphasizing gender, marital status and organizational class) and Spearman correlation coefficient (to determine criteria of Training and Development of Excellence Model in current and desired status) were used.

The main variables were studied in PRELIS in research process, and assumptions of parametric statistics were calculated with an emphasis on normality of multivariate distribution and nonresponse ratio less than 0.5 and were investigated using LISREL software for the variables under study. Pearson correlation relationship was tested between the five variables (based on the conceptual model) by SPSS 19 software; According to this relationship and its significance, the causal relationship of these variables was tested through structural equation modeling using LISREL 8.72. Then, factor analysis is conducted; after designing the mentioned model, its fitness is investigated using experimental data emphasizing factor analysis and path analysis,.

III. FINDINGS

The first goal: investigating the Criteria indices of corporate educational excellence in current and desired status in Iranian Mines and Mining Industries Development and Renovation Organization based on Training and development excellence Model.

Table 2: t-value of two correlated groups to study Training and Development Model criteria emphasizing both current and desired status

Items	Level	Mean	Standard Deviation	T-value	Degree of freedom	Significant level
training and development leadership	Current	15 .48	6 .43	-29 .37	116	0.001
	Desired	30 .86	3 .33			
learning and development culture	Current	15 .93	6 .36	-27 .97	121	0.001
	Desired	30 .63	3 .59			
training and development strategy	Current	16 .48	6 .17	-28 .36	118	0.001
	Desired	30 .31	4 .02			
educational needs assessment	Current	35	13 .19	-30 .01	116	0.001
	Desired	70 .06	8 .09			
Educational planning and design	Current	45 .7	15 .8	-20 .45	114	0.001
	Desired	75 .23	10 .41			
training executive management	Current	36 .75	12 .51	-19 .60	118	0.001
	Desired	60 .47	8 .25			
Educational assessment	Current	15 .15	6 .63	-22 .61	119	0.001
	Desired	28 .53	4 .74			
Educational performance results	Current	35 .99	12 .31	-23 .03	110	0.001
	Desired	60 .72	7 .59			
Organizational key results	Current	18 .55	7 .63	-20 .97	116	0.001
	Desired	32 .99	2 .77			

According to the above findings and emphasizing the obtained t-value, it is concluded that there is a significant differences at $\alpha=0.01$ between the research subjects in "training and development leadership", "learning and development culture", training and development strategy, educational needs assessment, training executive management, educational planning and design, processes assessment and monitoring, performance results, Organizational key results, empowerment, processes and results variables focusing on the present and desirable situation. Therefore, it can be stated that there is a significant gap between current and desired status of the components of the Organizational Educational Excellence.

According to research findings and the remarkable gap between current and desired status of the organizational educational excellence criteria, it can be said that it is possible to implement Training and Development Excellence Model in the Iranian Mines and Mineral Industries Development and Renovation Organization.

The second Goal: prioritizing Training and Development Excellence Model in the Iranian Mines and Mining Industries Development and Renovation Organization

Based on research findings, in Training and Development Excellence Model deployment in the Mines and Mineral Industries Development and Renovation Organization of Iran, the "results" criteria are the first and "enablers" are the last priorities.

Table 3: Prioritizing the components of the training and development model

Row	Criteria	Mean	Priority
1.	Organizational key results	4 .635	First
2.	training executive management	4 .603	Second
3.	educational planning and design	4 .535	Third
4.	performance results	4 .420	Fourth
5.	Educational needs assessment	4 .336	Fifth
6.	training and development strategy	4 .120	Sixth
7.	learning and development culture	3 .977	Seventh
8.	training and development leadership	3 .877	Eighth
9.	Educational assessment	3 .777	ninth

Summing up scores received by the Iranian Mines and Mining Industries Development and Renovation Organization using the questionnaire sent for staff, considering the weight of each sub-criteria show that the organization will be placed in three stars crystal statue position with 432 points. The organizations in this status are those that are in acceptable stages of dedication to educational excellence. Of course this rating is achieved according to the respondents' lack of proficiency in RADAR logic and lack of knowledge about the assessment methods of the excellence models and therefore, it is not reliable. So with regard to this issue and the results of previous studies provided in the literature, some executive suggestions presented are provided.

The third goal: providing desired model of education for the Iranian Mines and Mining Industries Development and Renovation Organization in factor analysis stage, with an emphasis on Eigen Value greater than 1.5, which is referred as Loading Factors. After exploratory factor analysis (EFA), it was determined that empowerment, processes and results were considered as the main factors and these factors were proposed as observed variables.

In addition that fitness theoretical model has appropriate experimental-theoretical assumptions within the path analysis, it can be interpreted that the training and development leadership, learning culture, training and development strategy, educational needs assessment, educational executive management, educational planning and design, assessment and monitoring processes, performance results and organizational key results have direct positive effect on empowerment, processes and results.

Figure 2 indicates the result of structural equation modeling. This figure represents a standard coefficient (R) and the proposed causal relationship between the training and development leadership, learning culture, training and development strategy, educational needs assessment, training executive management, educational design and planning, processes assessment and monitoring, performance results, Organizational key results, empowerment, processes and results.

The model developed by LISREL software, eliminating the observed variables is as follows:

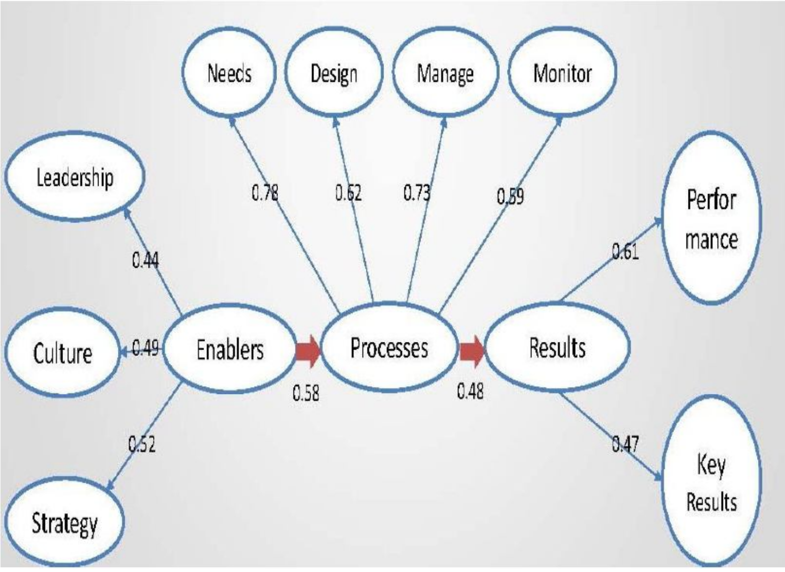

Figure 2: test outcome of causal relationship between the training and development leadership, learning culture, training and development strategy, educational needs assessment, training executive management, educational planning and design, processes assessment and monitoring, performance results, Organizational key results, empowerment, processes and results in significant status using LISREL software

Researcher has designed and offered a model for optimal training and human resource development system for IMIDRO based on comparative studies, collected information and findings of structural equation modeling that can be seen in Figure 3.

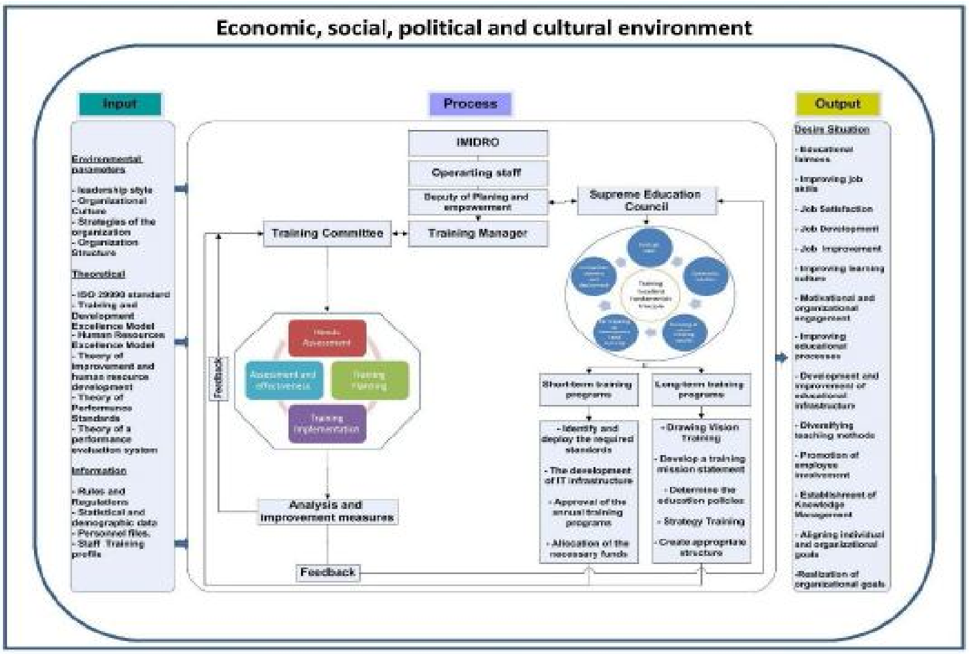

Figure 3: the model and conceptual framework of educational excellence and the development system of IMIDRO

The Fourth goal: validating the optimal model of education for the Iranian Mines and Mining Industries Development and Renovation Organization The proposed model and conceptual framework of educational excellence and development system of IMIDRO with a questionnaire with questions related to philosophy, purposes, theoretical fundamentals, principles governing the model, Implementation procedure, system evaluation, feedback and revision, usability and applicability of the model as well as a schematic model for evaluating validity and reliability is provided for 30 professionals and experts. Collecting and analyzing information was confirmed the proportionality of each of the parts.

Table 4: the model validation results from the professors' and experts' viewpoint

Row	Title	The mean score of professors and experts group
1.	Model Philosophy	4.6
2.	Model purposes	4.7
3.	Theoretical Foundations of the model	4.8
4.	Principles Governing the model	4.7
5.	Implementation phases of the model	4.7
6.	evaluation, feedback and revision System	4.8
7.	Usability and functionality	4.5
8.	All factors	4.7

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

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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.

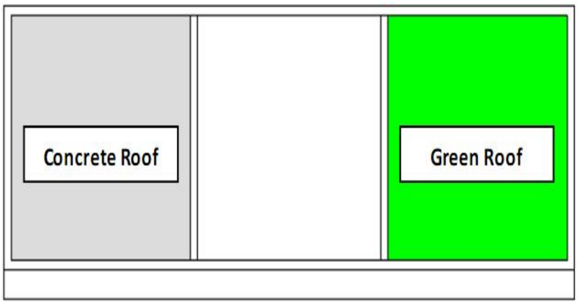

Figure: (1) The Plan's view of the experimental program.

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

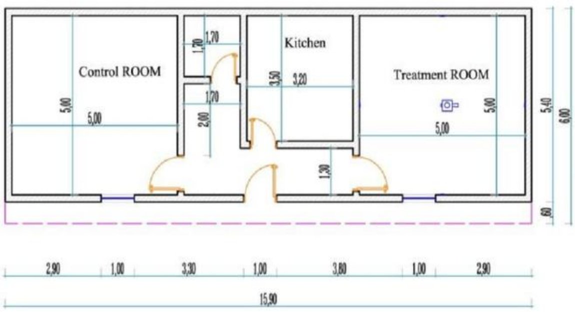

Figure: (3) A Plan's view of the rooms being tested.

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.

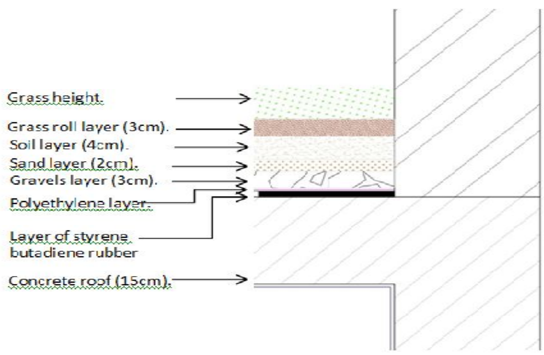

Figure: (4) The vertical section shows the various components of the extensive green roofing system

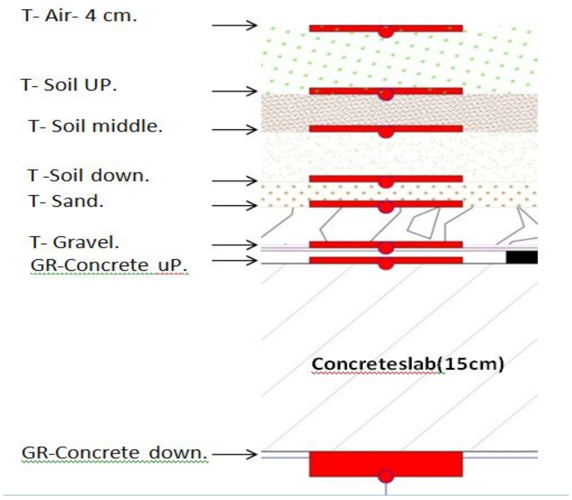

Figure: (5) The vertical section shows the sensors' places in the extensive green roof system.

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

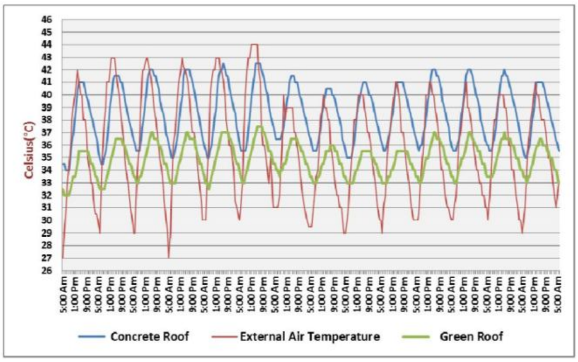

Figure: (7) Temperature variation of the internal air temperature in treatment room and control room with tall grass during the time period from 6-6-2014 at 5:Am to 20-6-2014 at 5:Am.

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.

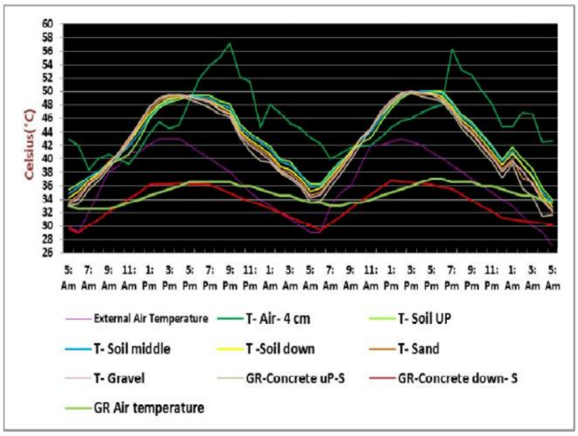

Figure: (8) Temperature variation of substrate layers with tall grass (regular irrigation) during the time period from 7-6-2014 at 5: Am to 9-6-2014 at 5:Am.

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.

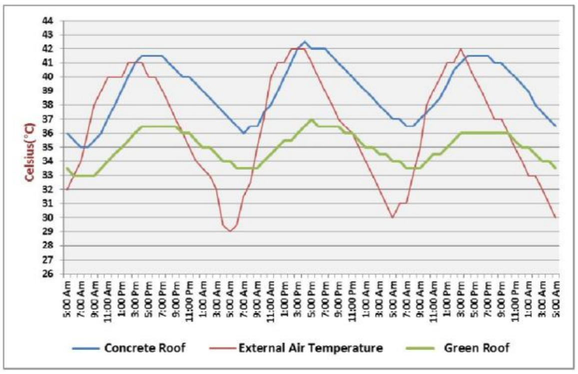

Figure: (11) Temperature variation of the internal air temperature in test rooms with short grassduring the time period from 20-6-2014 at 5:Am to 23-6-2014 at 5:Am.

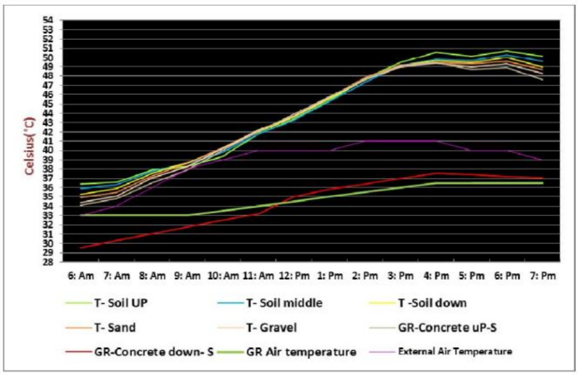

Figure: (12) Temperature variation of substrate layers with short grass (regular irrigation) during the time period from 20-6-2014 at 6:Am to 20-6-2014 at 7:Pm.

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.

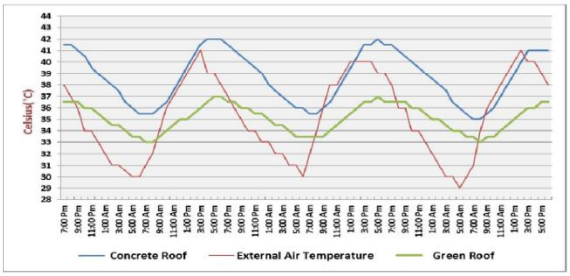

Figure: (14) Temperature variation of the internal air temperature in treatment room and control room with tall grass (first day irrigation, next day off and third day off too) during the time period from 160-6-2014 at 7:Pm to 19-6-2014 at 5:Pm.

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.

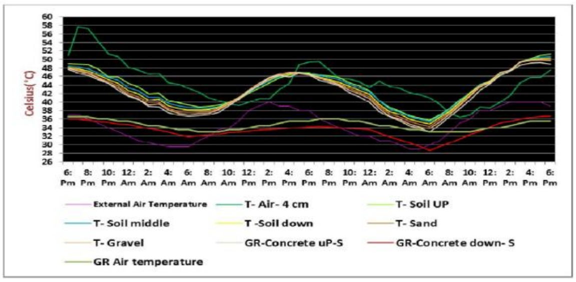

Figure: (15) Temperature variation of substrate layers temperature in extensive green roof system with tall grass (first day irrigation and the second day off) during the time period from 12-6-2014 at 6: Pm to 14-6-2014 at 6:Pm.

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.

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

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

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

I. INTRODUCTION

Demand forecasting is crucial for supply chain management. Production planning, inventory management, and manufacturing scheduling are typically formulated according to short- and long-term expected demand [1]. To reduce the occurrence of delivery delays caused by the "crowding out" effect of manufacturing processes, contemporary enterprises have gradually changed their production patterns from make-to-order (MTO) to make-to-stock (MTS), and increasingly fewer enterprises are using the MTO production strategy [2 , 3]. The MTO production involves commencing product production only after the customer places the order. The MTS production pattern entails a stocking-up production, in which a company manufactures products and stores them in inventory before customer orders are received. Subsequently, the company sells its stock as customer places orders. If a company receives orders requesting a high mix of products but in low volumes, it must be capable of forecasting their order demand accurately before attempting an MTS production strategy. Accordingly, the advantages of the MTS production strategy—including quick delivery, arranging a long-term manufacturing schedule, reducing the stock levels, and stabilizing product prices—can be realized. Worldwide, variation in customer demand has forced many manufacturers to adopt a high-mix low-volume production model. However, this type of enterprise is not as efficient as a low-mix high-volume enterprise. Therefore, determining how high-mix low-volume enterprises can enhance their business operation performance urgently requires a solution. Hence, accurately forecasting order demand is a fundamental to successfully applying the MTS production strategy to a high-mix low-volume business operation model. Because inaccurate demand forecast is a concern for high-mix low-volume enterprises, the MTO production strategy is typically adopted. However, this production pattern increases financial risks and requires a long delivery time, making centralized production difficult, which subjects production lines to frequent changes, resulting in high operating costs and low product quality. Complex operations are the primary cause of human error and low job satisfaction. Therefore, if the inefficiency of the high-mix low-volume business operation model cannot be solved, then, despite a high business revenue, business operation costs would increase rapidly, product quality would reduce, and employee job satisfaction and customer satisfaction would decrease, which result in that business development would stagnate. Therefore, the forecasting method proposed in this study can provide a crucial basis for transitioning from using the MTO to the MTS production, and may offer a viable solution for improving the business operation performance of high-mix low-volume enterprises. The application and improvement of the proposed forecasting method can assist researchers with understanding the characteristics of business operations and construct related business operation models. Forecasting ability depends on crucial information and reliable forecasting methods. In recent years, demand forecasting has become increasingly complex, primarily because the global economic environment has gradually changed. The underlying reasons for this change can be explained in terms of the following four dimensions: volatility, uncertainty, complexity, and ambiguity (VUCA) [4 , 5 , 6], all of which have been shown to influence demand forecasting [7]. Volatility means that new products are rapidly developed, product lifecycles are shortened, customer preferences change suddenly, and organizations are frequently restructured; consequently, historical data diminishes in value. Uncertainty refers to unknown factors that cause sudden shifts in demand, and these factors are generally regarded as outliers or interferences. Complexity means that the interaction of these influential factors cannot be modelled easily, and ambiguity refers to fuzzy events and situations that cannot be quantifiably defined, leading to the loss of key influential factors. In summary, according to the influence of economics on demand forecasting, developing a reliable forecasting method requires analyzing whether historical data can contribute to demand forecasting, and whether the effects of influential factors can be identified. To meet the requirements of modern forecasting methodologies, this study proposed using linear mixed-effect models to perform forecasting. Linear mixed-effect models have been extensively developed and widely applied in various fields. However, no study has used this model to forecasting in business operation. Linear mixed-effect models are characterized by the inclusion of temporal factors and explanatory variables and the analysis of their significance. Accordingly, crucial influential factors can be identified to forecast demand. These characteristics fulfill the requirements of modern forecasting methodologies and can be used as the basis for companies to improve their operation efficiency and to develop competitive advantages. The following sections explore the influences of the MTO and MTS production strategies on business operation as well as the role of forecasting in the MTS strategy, provides a review of the literature on forecasting methodologies, and summarizes the strengths and weaknesses of commonly used forecasting methods. In addition, the proposed linear mixed-effect model as well as a method for model parameter estimation are introduced. Subsequently, the order demand of a manufacturer in central Taiwan is forecasted using product type as a crucial explanatory variable. Specifically, the linear mixed-effect model is applied to forecast the order demand for 20 individual product types. A 1-year forecast of monthly demand is reported, and three types of forecast errors are used to assess the forecasting ability of the model. The results show that the forecasting ability of the linear mixed-effect model in an empirical analysis is superior to those of a linear forecasting model, exponential smoothing method, and time-series forecasting method.

II. LITERATURE REVIEW

A. Influences of the MTO and MTS on Business Operations

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

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

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

B. Forecasting Methodology

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

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

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

Table 1. CHARACTERISTICS OF 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 $\mathrm{l}(\boldsymbol{\beta},\boldsymbol{\theta}) = \ln L(\boldsymbol{\beta},\boldsymbol{\theta})$.

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.

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

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

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

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.

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

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:

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

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:

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

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

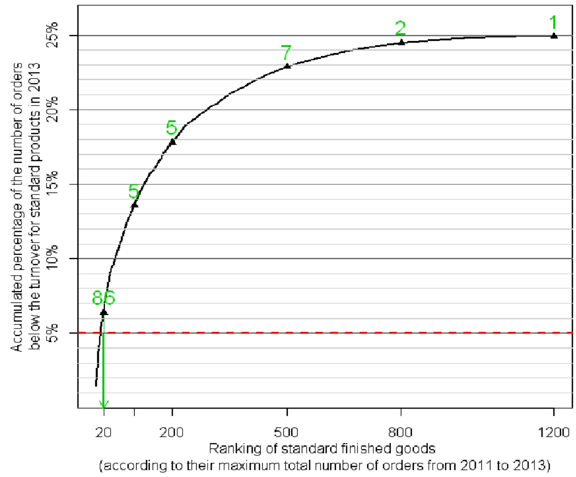

Figure 1. Maximum total number of orders (2011–2013). The plot shows that the accumulated percentage of the maximum total number of orders from 2011 to 2013 is less than the turnover of standard products in 2013. The first 20 products accounted for approximately 20% of the turnover for of standard products. 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 ($N \le 6$).

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

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

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

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