

**THE REPUBLIC OF TURKEY
İSTANBUL KÜLTÜR UNIVERSITY
INSTITUTE OF GRADUATE STUDIES**

**A NOVEL APPROACH FOR IMPROVING PROFITABILITY
IN THE CONSTRUCTION INDUSTRY**

MASTER OF SCIENCE THESIS

By Bashir Hussain Heidar

Department: Industrial Engineering

Program: Engineering Management

Supervisor: Assist. Prof. Duygun Fatih DEMİREL

NOVEMBER 2022

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LIST OF SYMBOLS

x_i	<i>Project i</i>
cst_i	<i>Cost of project i</i>
pft_i	<i>Profit of project i</i>
Cst_s	<i>Total cost of selected projects</i>
Bgt	<i>Total budget available</i>
Pft_s	<i>Total profits of selected projects</i>
Dur_s	<i>Number of total days needed for executing the selected projects</i>
D	<i>Available working days for executing the projects</i>
d_i	<i>Necessary days to complete project i</i>
N_s	<i>Number of selected projects</i>
N_U	<i>Number of unselected projects</i>
N_A	<i>Number of all projects under analyzing</i>
N_{at}	<i>Number of total attributes under analyzing</i>
CI	<i>Couple Index</i>
$CI_{ij}S$	<i>Couple Index value of a_i and a_j attributes for selected projects</i>
$CI_{i,j}U$	<i>Couple Index value of a_i and a_j attributes for unselected projects</i>
$CI_{i,j}A$	<i>Couple Index value of a_i and a_j attributes for all projects</i>
AI	<i>Accompany Index</i>
AIS	<i>Accompany Index of selected projects</i>
AIU	<i>Accompany Index of unselected projects</i>

AIA	<i>Accompany Index of all projects</i>
$AI_{a_i}S$	<i>Accompany Index of a_i in selected projects</i>
$AI_{a_i}U$	<i>Accompany Index of a_i in unselected projects</i>
$AI_{a_i}A$	<i>Accompany Index of a_i in all projects</i>
a_i	<i>Attribute i</i>
a_j	<i>Attribute j</i>
$N_S a_i a_j$	<i>Number of the selected projects, which included of a_i and a_j at same time</i>
$N_S a_i$	<i>Number of the selected projects, which the a_i available on it</i>
Ctg	<i>Category</i>
N_{ctg}	<i>Number of existing attributes category</i>
$Ctg_p a_i$	<i>Category “p^{th}” of couple index in the field of attribute “i”</i>
DR_{a_i}	<i>Distance ratio of attribute a_i</i>
RW_{a_i}	<i>Ribbon width size at the point of attribute a_i</i>
$Di_{SU} a_i$	<i>Distance between the values of a_i in selected and unselected projects</i>
$Di_{SA} a_i$	<i>Distance between the values of a_i in selected and all projects</i>
$Di_{AU} a_i$	<i>Distance between the values of a_i in all and unselected projects</i>
$Max_{Ctg_p a_i} S$	<i>Max. CI value of a_i in the category p of selected projects</i>
$Max_{Ctg_p a_i} U$	<i>Max. CI value of a_i in the category p of unselected projects</i>
$Max_{Ctg_p a_i} A$	<i>Max. CI value of a_i in the category p of all projects</i>

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ÖZET

İNŞAAT SEKTÖRÜNDE KARLILIĞI ARTIRMAK İÇİN YENİ BİR YAKLAŞIM

Bashir Hussain HEIDAR

Şehirlerde nüfus artışı ve nüfus yoğunluğunun artması ile inşaat sektörü önemli ölçüde büyümüştür. Kule ve gökdelenlerin sayısı her geçen gün artmaktadır. Bu artış sebebiyle dikey ulaşım ihtiyacı vazgeçilmez bir hal almış, böylece birçok asansör firması ortaya çıkmıştır. Asansör firmalarının yaşadıkları en büyük zorluklarından biri sektördeki diğer firmalarla rekabet edebilmektir. Pazarda şirket kurmak, müşterileri ürün ve asansörlerini almaya çekmek, müşterilere hizmet vermek, satış ve pazarlamada doğru bir plan yaparak asansör şirketlerinin iş ve finansal gücünü geliştirmek, şirket yöneticilerinin ve kurucularının ilgilenmeleri gereken kritik konulardır. Şirket yönetimi, mevcut asansör şirketlerini ve bu sektördeki müşterilerin ihtiyaçlarını analiz ederek, şirketlerin zayıf ve güçlü yönlerini bulabilir ve buna dayalı olarak pazarda daha fazla müşteriye hizmet vermek için daha iyi bir strateji benimser. Bu çalışma, bir firmada karlılığın iyileştirilmesine yardımcı olmak için Eşlik Endeksi Yöntemi (AIM) olarak adlandırılan yeni ve kullanışlı bir uygulama sunmaktadır. Bu yenilikçi yöntem ile, müşteri taleplerinin türü, proje bölgeleri bölümü, ürün ve hizmet türü incelenerek ve diğer proje detaylarını farklı nitelik kategorilerinde organize edilerek uygulanmaktadır. Dubai'de yerleşik bir asansör firmasının verilerine uygulanan AIM uygulaması, bu firmanın yönetimine asansör modernizasyonu ve parça satışını göz

önünde bulundurarak projeler gerçekleştirme konusunda rehberlik edecek. Ek olarak, sonuçların tercümesi, “villa asansörleri”, “bakım” ve “asansör onarımı” gibi bazı özelliklerin yüksek karlı projeleri filtrelemek için AIM'de dikkate alınmaması gerektiğini göstermektedir. Bağımlı özniteliklerin ve bağımsız özniteliklerin aynı anda ele alınması, AIM Yöntemden diğer analiz yöntemleriyle olan avantajı ve farkıdır. Bazı durumlarda, bir öznitelik koşulundaki iyileştirme, paradoks olan diğer karlı öznitelik iyileştirmeleri üzerinde zıt bir etki yaratacaktır ve “AIM” ile bu paradoks çözülecektir.

Anahtar Kelimeler: Çift endeksi (CI), Eşlik endeksi yöntemi (AIM), Proje özellikleri, Satış ve pazarlama, Karar verme, Proje değerlendirmeleri

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ABSTRACT

A NOVEL APPROACH FOR IMPROVING PROFITABILITY IN THE CONSTRUCTION INDUSTRY

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With the increase in population and population density in cities, the construction industry has grown significantly. The number of towers and skyscrapers are increasing every day. The need for vertical transportation is one of the irreplaceable needs. Hence, many elevator companies have emerged. One of the main challenges for elevator companies is to compete with other companies in the industry. Establishing a company in the market, attracting customers to buy their products and elevators, serving customers, and developing the business and financial strength of elevator companies by having a proper plan in sales and marketing are the critical issues of managers and founders of companies. By analyzing the existing elevator companies and the needs of customers in this industry, company's management can find the weaknesses and strengths of the companies and based on it, adopt a better strategy to serve more customers in the market. This study provides a novel and useful method, named as Accompany Index Method (AIM) to develop in profitability in a firm. The novel and innovative method is implemented by examining the type of customer demands, project regions division, products and services type, and organizing other project details in different categories of attributes. The AIM method applied to the data of an elevator

company located in Dubai, which will guide the management of this company to perform projects by considering elevator modernization and sales of the parts. In addition, the translation of the results shows that some of the attributes like “villa lifts”, “maintenance” and “elevator repair” should not consider in AIM to filter the high profitable projects. Considering the dependent attributes and independent attributes at the same time is the advantage and difference of AIM method with other analyzing methods. In some cases, improvement in one attribute condition will give an opposite effect on other profitable attribute improvements, which is the paradox, and with “AIM” this paradox will solve.

Keywords: Couple index (CI), Accompany index method (AIM), Project attributes, Sales and marketing, Decision making, Project evaluation

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1. INTRODUCTION

The existence of elevator companies in the construction industry is an irreplaceable need. Skyscrapers and towers are on the rise due to the influx of people into cities and overcrowding, along with the establishment of many elevator companies (Yanbin, 2020).

The expansion of the elevator industry in the market has faced elevator companies the challenge of competing with other parallel companies. On other hand, customers are looking for elevator contractors with a high ranking for safety, and quality with reasonable costs (Nima, 2020). Therefore, competition between a high volume of competitors in the market to develop business and boost sales and service on a larger scale has always been a challenge for the management team of each business.

To grow and develop business and have wider sales and services, companies need to have the technical and expert sales and marketing team those who are able to analyze the market and customers and determine the products and services according to the high amount of certain demands.

The novel approach proposed in this study, namely Accompany Index Method (AIM), works by considering these demands and effective factors on them to giving a better understanding of market and create best business plan and decision accordingly.

To apply the AIM, it is necessary to describe the attributes such as the services and product types. As summary, the elevator companies operate in the market by providing full elevator packages, spare parts sales, installation services, modernization of elevators, and maintenance of existing projects.

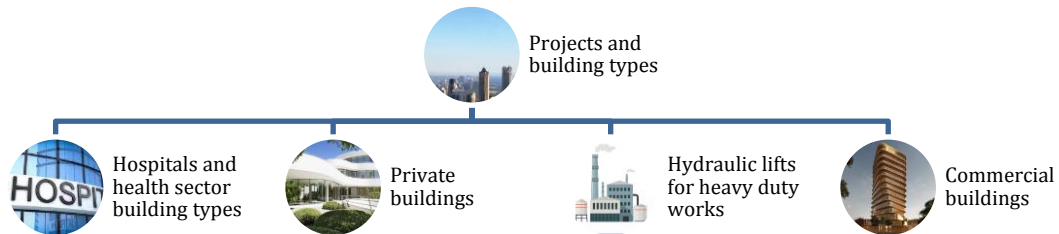


Figure 1.1: Different elevator usage categories

The building types, which divided into different categories in Figure 1.1, are the one of essential attributes that are necessary to apply AIM method.

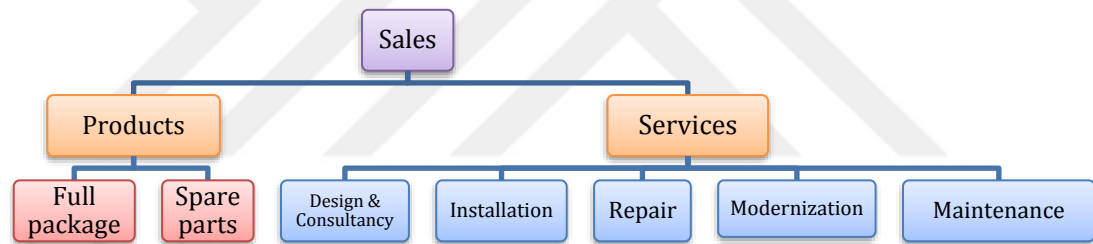


Figure 1.2: The sales type diagram

Figure 1.2 shows the type of products and services for sales in the elevator company. If the demand in market increase, the sales quantity will increase accordingly.

The lifts, escalator and moving walkway (travellator) are the products, which can produce in the elevator industry. Moving walkway (travellator) is a fast, safe, and comfortable product for moving a high volume of passengers to higher or lower elevations horizontally, which can be used in malls, airports, subways, and public areas (Otis, 1955).

1.1. Aim of The Research

One of the key factors in promoting sales is having the right strategy based on the needs of the market which other competitors are not able to fulfill. Managers and the sales team are looking to find out and analyze the needs of customers, and recognizing the strength and weaknesses of competitors in the market. For this purpose, they must first describe the services of elevator companies, then examine the type of customer demand based on different project types, and finally find out, the weakness and strengths of competitors based on market, customer, and demand analyses. The main aim and purpose of this thesis are to provide a novel approach - Accompany Index Method (AIM) - to improve profitability. With help of AIM, managers will be able to plan and report to the top management to control and manage all departments such as operation department, sales department, Marketing department, R&D department and etc. according to the outcome of AIM method.

The method used in this study is analyzing the client requirements preference and categorizing the demands of customers, which are looking, to install or modernization their elevators in the building. By considering the customer needs in different territories and collecting these data from different projects, the sales department will be able to promote and offer the products accordingly for better outcomes. Customers and demand volume are the factors that are proportional to sales and on the opposite; the competitor is in inverse relationship with sales volume. Accordingly, the effective attributes, which are influence customer and competitor quantity, are such as:

- Innovation
- Interior design
- Technical design
- Safety
- Quality
- Maintenance cost
- Utility cost
- Risk knowledge
- Investment and budget capacity

1.2. Thesis Questions

Managers strive to find the best solution for improving sales in the market such as “what product or product features are expected by the customer?”, “how much budget should be allocated for advertising and marketing?”, how many people should be hired in sales?” or “which kind of strategy according to key factors of sales shall be considered?” (Kotler, 1999). With this study, the reader will find the answer to the following questions:

1. What can the manager do to increase sales volume in an elevator company?
2. How can the management analyze the strengths and weaknesses of the competitors?
3. What types of products or services can be suitable for certain markets and customers?
4. What effective project attributes can filter high profit projects?

The scale of ranking between effectiveness sales factors will come out from analyzing the previous project performance of the companies in certain markets and products. With the high weight attributes, the decision will lead the organization to be much near to the financial and net profit target. The purpose of the AIM method, which is working to analyze the previous projects, will answer the above questions.

1.3. Research Contribution

By addressing the above questions, the main and essential attributes will be examined and analyzed to separate them according to the market variation in different places and times. Based on the specific needs of the same region, the company's products and services can be controlled and planned in terms of quantity and quality. Competitive companies' indicators are examined to find the weaknesses and strengths of competitors so that the proposed plans can be implemented based on market conditions and competitors' roles there.

By answering the questions above, it will be clear and obvious how the sales engineer will be able to offer and price the product in beneficial price and product options. The results will give the best decision that the sales engineer can offer the customers to attract them and make the contract.

There are some methods like as multi-factor regression analysis, correlation, ranking the effective factors method, factor rating method, etc., to find profitable and suitable contractors for construction projects or profit maximization. The method, examined in this study (AIM), is a novel method and it is a method performed for the very first time. This method considers all attributes and factors together and in this method, all attributes have a relation like a chain. That is why it is named as “Accompany Index”.

1.4. Scope and Structure of This Thesis

Competing with competitors in any kind of sector needs to analyze the market, customers, products, and services that the company provides. The elevator companies are one of the essential needs for the construction industry or let us say for a new lifestyle in the world because transferring people between the floors in towers and high-rise buildings is an important matter, which cannot ignore. This thesis tries to find the solution for analyzing the elevator company projects history to filter the high profitable projects and describing the attributes, which has a high potential effect for choosing projects from all of projects history as highly profitable projects with having a certain budget or certain investment duration. In the first step, the elevator company’s product and services are detailed to describe the attributes and factors. In the literature review part (Section 2), some related studies by other researchers are examined. These researches are about finding the best contractor for building maintenance. The previously offered methods are analyzing contractors with the multi-criteria decision-making application, ranking the factors and multi-factor regression analysis. After Section 2 the novel method, named as AIM is introduced in Section 3 and it is implemented in the case study of the elevator company in the United Arab Emirates in Section 4. In the methodology part, all steps to calculating the AI and CI values are described. The AI and CI are the set of values, which the range of those values is between zero and one. Each attribute for the project has one AI value. The way of using the AI value is explained in the methodology part. In the next stage, translating the AI and CI to the clear statement is illustrated. The result is shown in the arrow shape and diagram shape for a simple understanding of the outcome. Finally, the results of the AIM are explained in and the study is concluded.

2. LITERATURE REVIEW

In general, improving sales in the construction industry depends on multiple factors which are, time, location, innovation, potential competitors, resource availability, and price range. The attributes that give distinction between the companies are discussed in different research separately. For instance, the elevator kinds in certain territories as demand or customer type will be such potential factors for ranking and comparing contractors.

Several articles illustrated the effective factors for analyzing profitability. There are different articles that research done on the development of sales and marketing in construction companies, and these companies ranked in terms of profitability and product quality, and services in detail.

The key writings about the effectiveness of the potential factors in sales of construction industries are reviewed. The key factors that are important in elevator companies have been examined separately in various articles, which are mentioned hereafter.

By considering the sales factors, which influence profitability, different strategies provided for different customer types. According to the products and services demand, investment and sales will grow. The statistics of customer demands show that general services such as maintenance, changing spare parts and modernization have around 47 percent of elevator companies' service contracts from all contract types. In such an industry, focusing on the services will be effective accordingly (Yanbin, 2020).

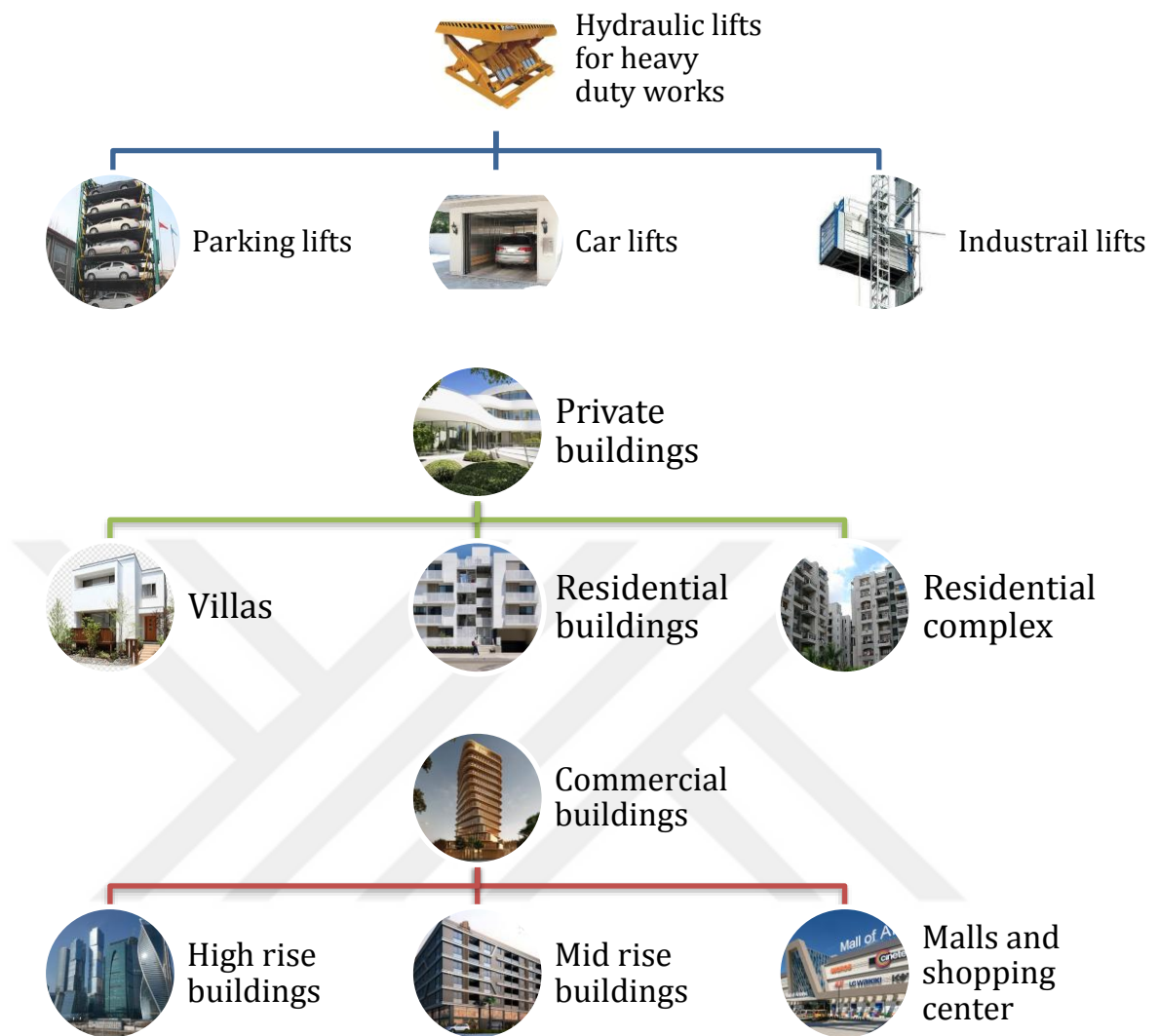


Figure 2.1: Project types that required elevators facilities

Each project categories extended in its subcategories as shown in Figure 2.1. Hydraulic lift usage is for industrial and car lifting sectors, because of its heavy-duty capability. The private building is included villas, residential buildings, and complexes. Commercial buildings divided into three categories by considering the height of the building.

This kind of separation will define the requirement and demands of customers. According to the demand, the resources and manufacturing the certain products will be chosen and produce.

2.1. Sales and Marketing and Key Writer

Philip Kotler, the father of modern marketing certainly mentioned the roles of innovation, understanding the key strength and weaknesses of competitors analyzing and approaching the market by considering the dynamic demand of customers. According to him, the sensational sustainability and eco-friendly improvement in products, services, and consultancy will increase the company's customers (Kotler, 1999).

2.2. Review of The Work Done by The Other Researchers

There are different methods that are used by other researchers for profitability maximization in projects. Factor ranking with scores or factor weighting is one of the methods for factor analysis. Making a questionnaire form to give weight to factors to compare the contractor is the most popular way of determining effective factor for profit maximization. Choosing a suitable contractor to have a high quality of work with reducing the cost is the way to maximize profitability (Kyssima, 2020). For instance researcher for using the factor ranking method described the factors for ranking the contractor as below:

- | | |
|---------------------------------|----------------------------------|
| ➤ Procedures of process | ➤ Technicians and staff |
| ➤ Management &
documentation | ➤ Tools and working
equipment |
| ➤ Regulations and rules | ➤ Cost of services |
| ➤ Communication | ➤ Quality and safety |

Profitability factors are including attributes related to cost and benefit. These factors could be the payback period, net present value, and internal rate of return, in the short term (one year), medium term (fine years), and long term (ten years) (Mantri, 2022).

Another method to analyze the factors is regression analysis. To determine the model for increasing the economic performance of enterprises, using the regression analysis technique is a great tool. Therefore the effective element and factors have to take from the previous and current financial statements and projects and after collecting the data, factors will filter and the coefficient for each factor will come out. This collection of factor coefficient data will be implemented in the multi-factor regression analysis formula (Burja, 2011).

Table 2-1: Mean score range details and coloring

SN.	Mean Score (M)	Ranking	Colour
01.	$4.0 \leq M \leq 5.0$	Critical/High Influencing Factor.	Yellow
02.	$3.0 \leq M \leq 3.9$	Moderate Factor.	Green
03.	$1.0 \leq M \leq 2.9$	Low-rate Influencing Factor.	Red

Table 2-1 is the mean score comparison details. The mean score is the sum average of the frequency response number of each score multiplied by the score of each cause over to the number of respondents of each factor (Kyssima, 2020).

Table 2-2: The ranking result

SN.	Profit Maximization Strategies Employed by the Small and Medium Size Building Contractors (SMSBCs).	T N R	MEAN	SD	R A N K
01.	Charging for all amendments on change orders,	78	4.34	0.877	6
02.	Accuracy on estimation of general conditions for profit,	78	4.32	0.702	7
03.	Pre-construction planning (PCP)	78	4.81	0.749	1
04.	Implementing technology (use of software and other planning and implementation tools),	78	4.01	0.946	10
05.	Moving towards shorter and team friendly contracts.	78	2.56	1.101	13
06.	Proper tendering procedure in relation to profit overheads,	78	4.78	0.985	2
07.	Onsite waste minimization, and the Green Innovation Strategy (GIS),	78	4.42	0.672	4
08.	Improving and increasing safety trainings,	78	2.38	0.520	14
09.	Timely execution of work on site,	78	4.34	0.876	5
10.	Better communicate, (communication between client and other consultants),	78	4.13	0.870	8
11.	Improving construction productivity and requirement on more job site experience,	78	3.87	0.804	12
12.	Converting one-time clients into recurring clients,	78	4.10	1.024	9
13.	Dropping Low Performers,	78	4.48	0.570	3
14.	Expanding the firm to reach a broader market.	78	3.91	1.100	11

Table 2-2 is a survey and answer to the questionnaire form result. A total of 94 questionnaires were distributed and 78 were returned. The ranking was calculated according to the case study results (Kyssima, 2020).

Different factors could influence a company's profitability in the short-term or long-term periods. Determination of effective factors is the essential tool for the management of a business entity. The methodology of recognizing the factors is to ask managers' ideas about the internal and external causes which have potential influence on profitability. This method is implemented on the multi-factor linear regression analysis.

The management role as a decision maker for having control in IT, R&D, and preparing the group of experts to analyze the effective factors of the business and have increased the profit is essential. Managers are responsible for all aspects and matters which affect the performance and results of each business. In this regard, Draker has a statement that mentioned the key factor of profitability in a business. Draker believes that every company has a distinct mission and policy that describes the business, target, identify certain customers, and values of the organization. The decided strategy will transmit these plans to the real workspace. Drucker argues that economic chain costing changes from cost-based pricing to price-based costing, in which the price that customers are willing to pay determines the costs. Therefore, the ability to organize customer information is the key factor in improving sales and profit. In addition, Drucker reminds us that because wealth creation is more important to companies than cost control, the collection of customer information will help managers to decide and choose better strategies and plans to develop wealth (Rosenberg, 1999).

Another method is multi criteria decision-making model. Some researchers come out with a model that uses multi-criteria decision-making methods and an artificial neural network model to find the best contractor that deals with customer requirements. For instance, in the elevator industry, the contractor who is able to find out the failure causes in lifts and diagnose and repair it with low cost and quick service is better than other contractors. Finding out suitable contractor using MCDM will help the building manager to have a great decision to choose the best contractor. Also, considering human factors based on the SHELL model and reflected in the Delphi method according to the multi-criteria application will help to choose the suitable contractor for building maintenance (Nima, 2020).

Table 2-3 shows the result of factor determination by the managers of Polish enterprises. (Agnieszka, 2019)

Table 2-3: External factors of a company's profitability

Division	Business cycles	Exchange rates	Mergers and takeovers	Good economic situation in global economy	High GDP growth rate in EU countries	Political/legal	Social - demographic	Sector in which company operates	Suppliers	Clients	Existing or potential competitors	International	Environmenta	Economic dimensions and factors	Technological dimensions	Social/cultural dimensions	Shareholders and owners	Strategic allies
Industrial environment																		
Competitive environment																		
General environment																		
Macro environment																		
Neighbouring environment –relations and businesses																		
Environment of an enterprise goals																		
Further nvironment																		
Near environment																		
External conditions																		
None																		

M. Majowska
A. Skowronek-Milczarek
E. Nowak
Kowalak
Bober
Campbell D., Hamill J., Purdie T.

L. Nieżurawski, G. Owczarczyk-Szpakowska
R. W. Griffin
K. Obłój
Siemińska
B. Gajdzik, B. Jama
Rokita

Table 2-3 is the result of factor determination with help of managers of Polish enterprises. The name of managers is colored under the table.

According to the result above manager will adopt a new plan and strategy. Increasing labor costs and exchange rate fluctuations will be new challenges for the company. To comes over these challenges, a new and suitable strategy for the growth of sales will lead the company to prepare new opportunities for developments in the market (Otis, 2020). Collecting data from projects and customers are necessary for analysis and maximization of profit and customer satisfaction. By analyzing the

collected data from customers Otis elevator company decided to increase the 30% of investment in the R&D department and some amount like as 20% for IT to support the Otis transformation for the next five years. The transformation to digitalization in the product is a new strategy of product evolution to give a better and more innovative experience to the customer for improving satisfaction and sales (Galafassi, 2016). Also, OTIS to increase sales, implement a new strategy according to the analysis of the collected data from customers and give weight to factors. By the result of the analysis, they agree to improve the service and product variety and adopt new business to increase sales. United Technologies Corp., bought the Otis elevator to have a new business besides aviation business because of the slowdown of construction in China and the slow world economy and the power of USD in international sales as the company sees the opportunity to lead consolidation in the market. The acquisitions maybe have a 4-5 percent improvement in sales in the year 2020 in OTIS (Clough, 2016).

2.3. What Question Will This Research Answer?

This thesis works to create an method for analyzing the sales history of an organization to find out the high effectiveness factor on the sales. Analyzing the accompany indexes of projects, which will be the output of this thesis, can filter the attributes and with the high weighted factors used in project selection and accordingly, managers can determine and decide to choose strategy according to the determined effective factors. In addition, by using the solver application tools in MS Excel, the profitable projects will be selected from a number of different projects and by analyzing and measuring the result of those methods, it will be obvious the reliability of the outcome and selected decision. The outcome will solve the difficulty of decisions and planning and will answer the below questions:

1. How is it possible to create a method to find out the more profitable projects according to our investment budget volume?
2. Does the number of projects in sales matter or less project can be more profitable?
3. How should increase sales and maximize profit in a company?
4. How could recognize effective attributes in profitable projects?

2.4. Key Factors Influencing The Profitability of an Elevator Company

The factors of sales are the same in different industries. Innovation, decreasing cost of product and service, increasing the demand by improving the risk knowledge to the customer, quality, and safety improvement analyzed in different research separately. Different regions have different demands, so customer types can be divided according to their location. Some lift companies can fulfill customer demand while others do not. For instance, in modern cities, high-rise building elevators are mostly awarded to the top ten elevator brands which they are fulfilling the speed and capacity requirements. On the other hand, for villas and residential houses, many small companies with luxury and custom features give services to their customers. These attributes are analyzed to know which projects were more effective for the net profit. The selected project's attributes will give high weight to consider for choosing the proper plan. There are the number of factors that influence sales, which listed in Figure 2.2 below:

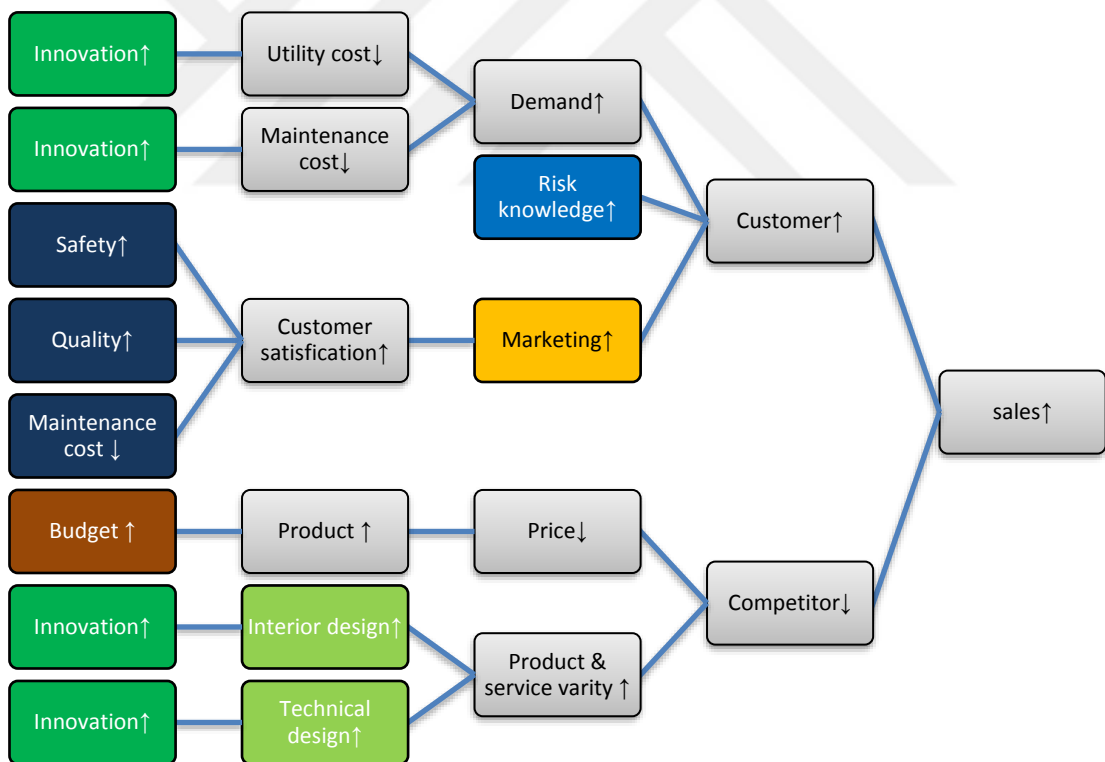


Figure 2.2: The attributes that affecting the company's sales

In Figure 2.2, the gray colored shapes represented the dependent variable attributes and the others are independent variable factors.

2.4.1. Innovation

One of the factors to improve sales is innovation. R&D department need to create new ideas and innovations to be unique resources for customers and compete with competitors by improving the variety of products and services, which finally increases the sales rate and profitability. In each kind of industry, the field of services and products are different. In the elevator industry, the innovation could be on interior design, technical design, speed, and type of motor and controller according to the job site condition. For instance, the innovation of an additional call button outside of the elevator car is a significant innovative tool for time optimization. Adding more sensors and cameras for collecting data from passengers to improve efficiency in scheduling is another innovation in the elevator industry (Hangli, 2018). Another innovation is in artificial intelligence uses the voice wake-up and recognition system to command the elevator. This system includes two parts, the Voice interaction part, and the smart control panel system of the elevator (Liu, 2021). This is a kind of contactless elevator call innovation. Innovation for the better quality of installation or maintenance and faster service performance are other aspects of sales improvement. The work in height and need for high precision work while working with heavy material is challenging for the operation team and it is time-consuming if using the classic method. Making robots for improving the installation speed and quality of work will improve the profitability of the company. For instance, the innovation of the guide rail robot's template for the guide rails installation is a great tool in this regard (Niu, 2021).

As mentioned before, following sustainability roles is an important factor to be in the market for a long time. One of the innovations, which could support this matter, is the innovation in the saving of electrical energy on the elevator control system, which is one of the key factors in sustainable development (Sirsi, 2017). Sustainability funded by three important factors: environmental protection, social justice, and economic development. Therefore encouraging people to use stairs instead of using the elevator is effective to develop sustainability (Griful, 2017). In 2020 because of safety against COVID 19 novel virus, innovation in the elevator industry created. For instance, contact-less elevator call like foot-kicking call buttons, gesture call with helping of a hand wave, making mobile application for elevator call and so many other kinds of elevator part innovations (Bo, 2020).

Double deck elevator

Two cabins hanging in an elevator motor are innovations to reduce the waiting time in public areas like shopping centers, business center, malls, etc. (Hirasawa, 2018)

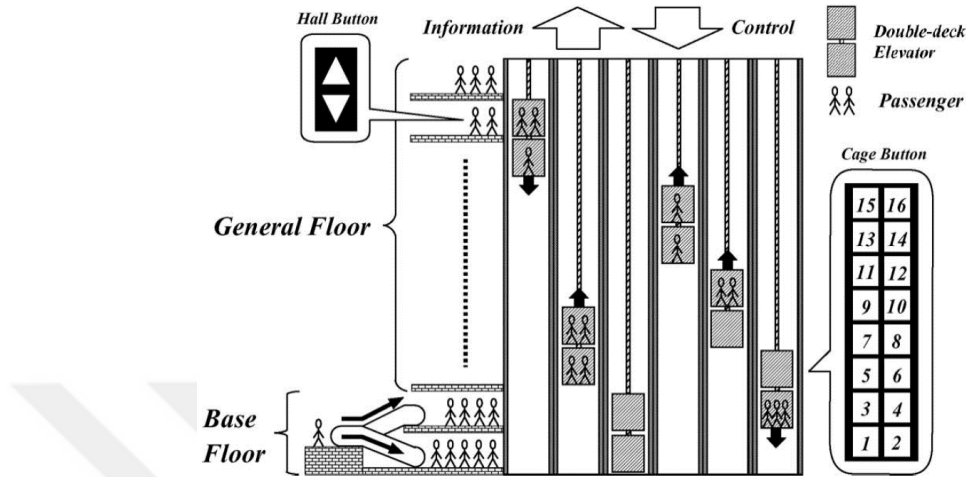


Figure 2.3: Double deck elevator

In Figure 2.3, the whole scheme of double-deck elevators is illustrated. Two cabins paired in one elevator shaft. It is a great solution for the high number of passengers in the projects with fewer places and fewer lifts quantity.

Supervisory system

Using the microcontroller which could be installed before the elevator drive system, will reduce power consumption, minimize the waiting time and traveling time between floors, and diffidently it will affect to reduce the cost as well (Sahu, 2020). With the development of artificial intelligence in different industries, artificial intelligence affected the elevator industry too. Artificial intelligence has improved the supervisory and group control systems in the elevator industry (Liting, 2017). The supervisor system will manage all elevator movement according to the passenger requirements to travel between floors to reduce the waiting time and increase the speed of service (Cortés, 2013).

With help of the group control system and monitoring elevators under the supervisory system, the number of calls will reduce and this approach consequence will save energy and reduce the cost and waiting time (Zhang J. , 2013). These privileges have benefits for the building owner by reducing the utility cost. With the marketing of this innovation for projects, the sales rate of the elevator parts will grow.

Interior design

Making custom design for elevator cabin interior design is one of the small elevator companies' advantages, which the worldwide brand are not able to fulfill the customer demand which requiring luxury elevators for his buildings. The managers of small elevator businesses can focus on villas and luxury buildings which the owners of building looking for custom and luxury interior design.

Technical design

Another privilege of small elevator businesses is to focus on projects in which the big brands and elevator manufacturers are not able to fulfill the customer requirement. For instance, in design and manufacturing, the small size lift with high capacity, pit-less elevator or temporary elevator for short time usage in some exhibitions or projects will be a great solution for these challenges.

The German engineering firm, ThyssenKrupp elevator company innovated the 10-meter height elevator by using a magnets system to shift the elevator cabin in horizontal and vertical direction which is illustrated in Figure 2.4. This great innovation will increase the opportunities and improve the huge sales amount in the market because it of lead to the evolution in the transformation industry such elevator market (Andresen, 2015). The steel rope used for hoisting heavy material in cranes or elevators and its structure made from several twisted steel wires with certain arrangements around the central core (Anil Babu, 2021). However using the carbon fiber composite belt is another solution instead of using the steel rope, which has low weight and high tensile and flexural strength, improving travel interval from 500 meters to 1000 meters, and reducing the machine's electric consumption (Kumar, 2020). But nowadays engineers innovated new elevator design which no need to use steel or belt type rope.

The ropeless elevator by moving in three dimensions works with the technology of linear motors and used magnetic flotation (Trochimczuk, 2017).



Figure 2.4: ThyssenKrupp revolutionary ropeless elevator

Figure 2.4 shows the new innovation which will cause the evolution in the elevator market that's led the innovator which is the German engineer firm ThyssenKrupp to have huge sales in the world. These MULTI kind elevators are the new generation of elevator industry which can put a MULTI cabin in one or more shafts and move the cabin in side way between the buildings and turn in the circuit of different shafts (Cesarz, 2020). These three-dimensional movements will change the elevator industry design. Using the rope in elevators installed in high-rise buildings has poor performance because the rope weight itself is a matter and on another side, the multi-car elevator could be made if using the rope less technic. Therefore rope-less elevator technology is an important innovation to improve efficiency and quality (Onat, 2013).

Passenger recognizer system

With this feature, the time efficiency of elevator service will increase and on the other hand, the elevator utility cost will decrease. Therefore, for high-volume passengers and elevator users such as commercial buildings, it will be a great item to sell and promote in this kind of building to improve sales.

Fingerprint system for security and collecting passenger data

Access to the elevator via fingerprint, allows the authorized people to use the elevator and entering inside the building. This feature is a great option for security proposed in residential buildings and complexes.

Automatic rescue device (ARD)

There is a high volume of inquiry for the ARD systems in the area, which has non-stable city electricity power. With electricity power interrupting, the passenger will be suffering from hanging inside the lift car. Sometimes people with close space phobia face danger because of this kind of situation. The best feature that can be offered for this kind of elevator users is the ARD system. This system will operate with a battery in case of electricity power interrupts and landing passengers on the nearest floor.

Regenerative system (GEN 2)

Using the elevator's energy regeneration unit (EERU) is a useful elevator part for reducing the energy consumption. An elevator that uses the EERU system for 30 days duration has 43 percent of electric energy savings with comparing to an elevator that does not have the EERU parts. (Marsong, 2016). There are two kinds of elevator movement, which have inertia energy that the regenerative system will store them. The elevator will use this stored energy in other lift movements instead of using the city's electricity. Storing braking energy and regenerative energy are the main applications of super capacitors in the regenerating panel in the elevator controller. (Mathew, 2017). This innovation decreases the utility cost because of using stored electricity instead the city's electric power.

Voice sensor for commend to elevators

This ability was the unique innovation to reduce the passenger touch with the elevator push button in COVID-19 time to reduce the physical touch because of virus dispatching. This innovation works and it is benedictional for seasonal or such a big extraordinary case which R&D team will release it on the time.

2.4.2. Safety (Importance of Old Elevator Safety)

The useful life of lifts in buildings is around 30 years (Zhang, 2022). Around 300,000 sets of lifts are under maintenance in China for 15 years time duration. Many old lifts are potential for safety hazards (Shuangchang, 2020). All industrial and non-industrial products have a certain lifetime and they can not be used after ending that time because of high risk. Given the useful lifetime of the material, it should be borne in mind that the elevator industry is no exception, and measures should be taken to replace worn parts. There is a worn shaft pin of the motor brake mentioned in Figure 2.5.



Figure 2.5: The motor brake shaft pin without safety clip

In Figure 2.5, the defective part of the elevator motor brake highlighted. This part of the motor has resistance and dynamic movement during elevator usage, therefore the safety spring clips are needed to maintain the part at the exact position all the time (Shuangchang, 2020).

The moving part has a less meantime between failures (MTBF) compared with other parts. The shackle rod springs installed on the heads of elevator ropes are no exception to these roles.



Figure 2.6: Broken springs of shackle rod in the elevator machine room

The Figure 2.6 shows shackle rods spring, which brooked after long time of usage under high-pressure total, lifts the weight.

The building owners should consider the lifetime of the elevator to maintain safety and reliability, therefore they will definitely need to contract with elevator companies for the elevator safety inspection to maintain safety and improve quality and reduce elevator consumption because of the low efficiency of old and expired parts. The quality of work in the elevator industry included quality in electrical and mechanical works. Smooth acceleration in start time and deceleration in stop time is the factor for testing the quality of installation works (Esteban, 2016). However, the quality of work in maintenance is critical and essential for the healthcare sector such as elevators installed in hospitals to avoid sudden deterioration (Reem, 2020).

In 2007 in china, the elevator renovation in the old building and townships has been one of the important matters with the priority of governments (Guo, 2019). A large number of elevators are installed in buildings and need maintenance. By researching and marketing to find this large volume of this kind of customers, the sales and marketing will succeed to make maintenance and modernization contracts by looking at old buildings.

Reliability and age of the component

The reliability at a given time is the percentage of failures at the same time. It is calculated according to the equation (2-1). (Morelli, 2000)

$$R = e^{-\lambda t} \quad (2-1)$$

In the equation (2-1), the parameter is defined as below:

- R = reliability
- λ = proportional failure rate
- t = time (hours)

The reliability range is the value between zero and one where one indicates hundred percent live components and zero indicates zero percent live components or failure on the system.

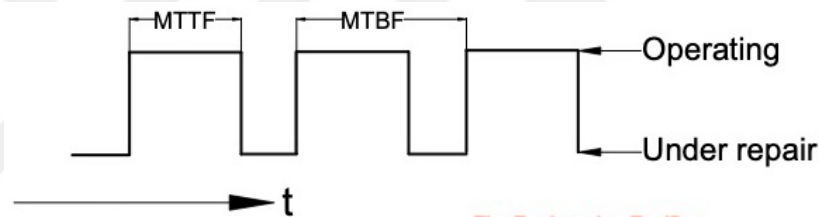


Figure 2.7: The mean time illustration by simple scheme

Figure 2.7 describes the difference between the MTTF and MTBF. The MTTF is the mean time to failure and MTBF is of the mean time between failures.

By statistics, more than eighty percent of faults will happen in the lift door operations, therefore quality of material and standard installation of the lift's door system is the critical thing that should focus. (Wang, 2012). A simple door operating system with proper installation will reduce the operating system maintenance cost.

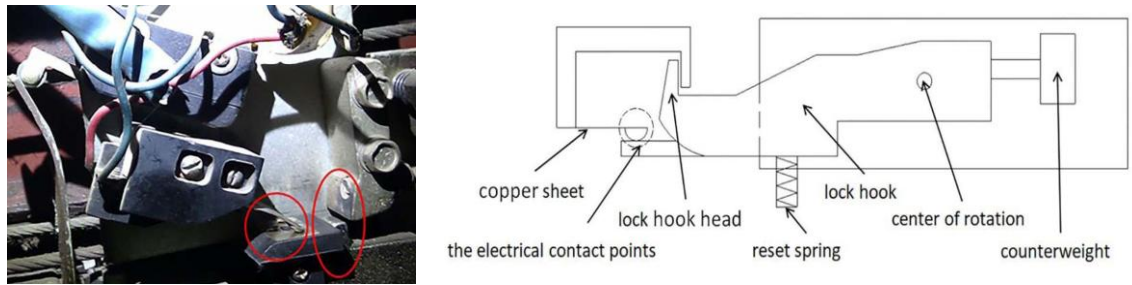


Figure 2.8: Hall door and car door lock scheme

The elevator doors lock is illustrated in Figure 2.8. This part of the elevator has low MTBT because of continual movement and forces with passengers in case of the closing door with ignoring the reopen sensors. Considering the high quality of installation and material indoor parts, lead the elevator contractor with reducing call back from the customers. This will increase customer satisfaction.

2.4.3. Utility Cost (Modernization of Old Elevator to Improve Efficiency)

Since the use of elevators is a necessary and undeniable thing in people's daily life, therefore reducing the lift usage cost in buildings is another challenge for customers and users. By modernization of the old elevators in buildings and using new models, the electricity consumption will reduce and the safety of elevators will be improve. Modernization of elevators will increase the elevator the speed and quality of transportation.



Figure 2.9: Elevator machine room – geared motor type with VVVF controller

In Figure 2.9, the 3VF controller is illustrated. Using variable voltage variable frequency controller instead two-speed elevators reduces the movement momentum and reduces the electricity consumption (Karlis, 2014). However, the gearless machine recently has more interest because of its smooth elevator movement and additionally compact motor design, high efficiency, low noise, simplicity in installation and maintenance, and no need to use oil for lubrication (Anand, 2016).

2.4.4. Maintenance Cost

Maintaining the building in good condition with periodic inspection has significantly affected the cost, risk, and performance of the building in general. The elevator is one of the items that have a high percentage of the total cost of a building. (Siti, 2018). Lift maintenance is described as the process to make sure that the lift works with the quality of the same as installation time with original equipment (Eappen, 2017). The quality of work will reduce the probability of failure repetition in the system. In addition, by analyzing the defective item, the reason for failure will be identified. By finding the solution to remove the causes of failure, the maintenance team will not face a call back again for the previous failure in the system. The innovation of mobile applications for fault diagnostic could be implemented to reduce the cost and time consumption during finding failure and solving the issue. The mobile application works by testing the noise and vibration of elevator movements (Gao, 2019). Evaluating the elevator work performance by analyzing the sound signal of the elevator door and elevator cabin is a method to diagnose the failures (Pan, 2021). By reducing the number of calls back of projects, the company cost for labor will decrease and on other hand, customer satisfaction will increase. In this scenario, the customer will play as the marketing team member for the company without paying.

2.4.5. Risk Knowledge

In 2019, a Chinese elevator company reported 5761 faults and 44 percent of the reasons for the fault is by improper use of the elevators by users (Yanbin, 2020). Informing society on social media about the way of properly using the elevators and the safety and risk importance may force the elevator user, to hire elevator companies to implement the inspections and services.

The customers mostly are not doing any action for elevator inspection until the elevator fails in such projects, which do not have a certain maintenance contractor.

2.4.6. Investment Budget Capacity

Defiantly, increasing the budget capacity will increase the product quantity. The high volume of products will help to reduce the price and with this strategy, the competitor will not be able to compete with the company because of price. Product manufacturing, having branches in different locations and allocating warehouses, etc., will affect to reduce the price of services and products, which will be a great advantage to compete with other competitors.

2.5. Method Applied in This Research

The case study in this thesis is to find effective attributes for profitable projects of a lift company in the United Arab Emirates. In the first step, the data set are organized. The project's costs, time duration, quantity, and net profit by considering the fixed investment budget and other attributes organized for each project. These data were collected in the Excel program. In the second step, need to filter profitable projects. To filter profitable projects need to use the solver to apply linear programming. The LP will help to filter the profitable projects. The result of the solver application in the Excel program is named the selected project. The projects, which are not selected, are named unselected projects. The summation of the selected and unselected project named as all projects. In the third step, need to find out the CI of selected, unselected, and all projects. In the fourth step, with help of the CI of those three kinds of projects, The AI of those three kinds of projects will calculate. In the fifth step, the AI value will be transmitted to the diagram and arrow shape to translate the number as a clear understanding of the result. These are all step to apply AIM.

Sometimes a high number of projects will give you less profit rather than a small number of projects because of the type of service or products. Recognizing the best strategy for products and services will lead the company to profitable investment and increase the sales rate. The result of the examined new method for analyzing the projects will contribute manager to have better decisions to select the profitable services and products accordingly.

3. METHODOLOGY

Filtering the most effective attribute for profitability and sales improvement in elevator projects is the aim of this study. To reach this goal, the AIM method will use. Figure 3.1 shows the implementation's steps of the AIM method:

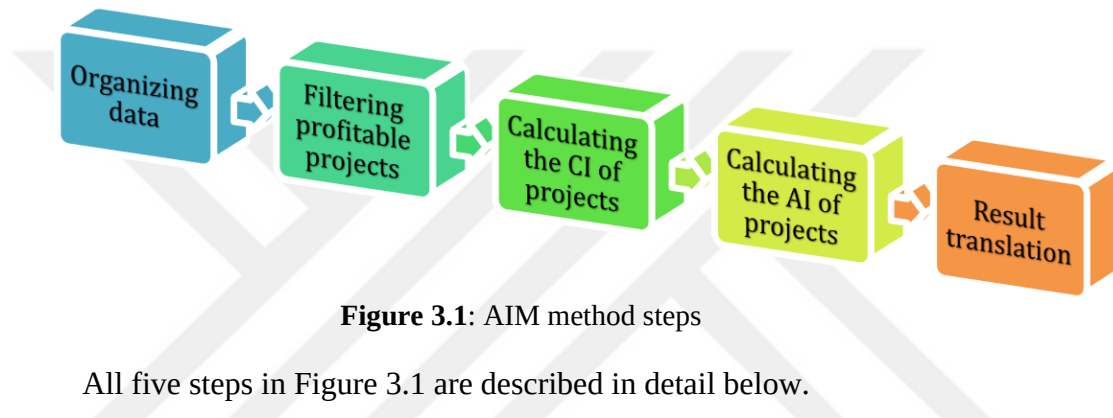


Figure 3.1: AIM method steps

All five steps in Figure 3.1 are described in detail below.

3.1. Raw Data Collecting for Analyzing The Projects

The data used for analysis should be taken from the records of the previous projects. Analysis of more projects provides better results for selection and decision-making. The information collected from the previous projects are organized into different categories and each category of information type may include several attributes and features. Different attributes could be determined from the projects, such as project technical specifications, project location, type of service and products, customer preference, type of customer, marketing type of contracted projects, project financial details, and time duration for each project. The categories of attributes are listed below:

1. Project details
2. Product types
3. Sales items
4. Customer preference
5. Building types
6. Marketing strategy

In this study, the raw data for projects are organized like as mentioned categories. Each category of data includes some attributes, which are displayed in Figure 3.2.

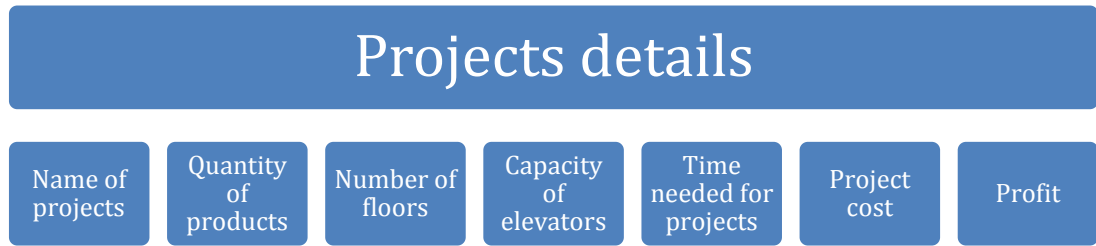


Figure 3.2: Project details attributes

Figure 3.2 listed the attributes. These attributes are taken from project technical and financial data.

Sales importance in a company is the same as the importance of the needs of the airplane to the fuel, and sales persons could be assumed as the engine of the airplane. Choosing the right product and service are very essential to starting up a business. In this study, the sales item divided into two parts as shown in Figure 3.3 as below:

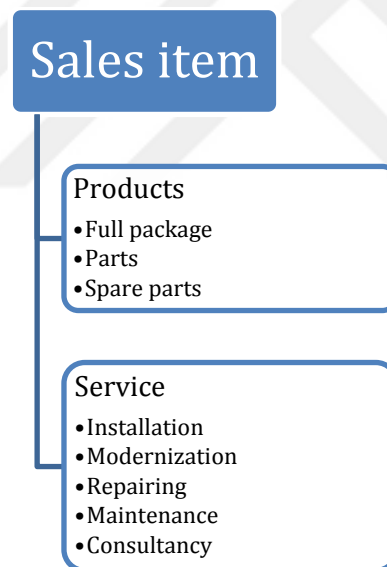


Figure 3.3: Sales item list of the elevator company

Figure 3.3 listed the items that an elevator company is able to provide for their customers.

Types of buildings and related elevator products are listed in Table 3-1.

Building types	Residential	Villa
		House
		Complex
	Industrial	Car lift
		Parking lift
		Factory lifts
	Commercial	High rise
		Midrise, Offices, Hotel
		Malls & public area
		Hospital & Disability
		Dumbwaiter

Table 3-1: Product kinds list according to the building types

Table 3-1 is listed all attributes, which separate building types.

The customer demand according to their preference in choosing the contractor is displayed in the radial diagram in Figure 3.4:



Figure 3.4: Customer preference for selecting the contractors

The customer's priority is to fulfill their demands mentioned in Figure 3.4, which could add more attributes for some other kinds of business and customer types.

3.2. Creating The Integer Programming Model

After gathering and organizing the raw data into the proper categories and listing the attributes under each category, the next step is to select the beneficial projects for fixed and certain budgets from the pool of projects. In that case, the integer programming models could be useful. The parameters, sets, and decision variables described below:

1) Parameters, indices and sets:

I : Set of projects where $i \in I, I = \{1, \dots, n\}$

cst_i : Cost of project i

pft_i : Profit of project i

Bgt : Total budget available

D : Available working days for executing the project

d_i : Necessary days to complete project i

2) Decision variables

$x_i = \begin{cases} 1: & \text{if project } i \text{ is selected} \\ 0, & \text{otherwise} \end{cases}$

3) Mathematical model:

If the total profits of selected projects is shown as (Pft_S) , the goal of the model will be to maximize the Pft_S :

$$Pft_S = \sum_{i=1}^n pft_i x_i \quad (3-1)$$

Subject to:

Budget constraint: if the total cost of selected projects is shown as Cst_S therefore:

$$Cst_S = \sum_{i=1}^n cst_i x_i \leq Bgt, \forall i \in I \quad (3-2)$$

Investment duration constraint: if the total duration of selected projects is shown as Dur_S therefore:

$$Dur_S = \sum_{i=1}^n d_i x_i \leq D \quad , \forall i \in I \quad (3-3)$$

Binary and integer constraint: If x_i represents project i , then:

$$x_i \in \{0,1\}$$

Here, “1” means the project x_i is selected as high profit projects and if it is “0”, the project x_i is not selected.

The constructed model can be implemented on GAMS or Microsoft Excel Solver App, Indeed, in this study; the model is implemented in Microsoft Excel.

3.3. Calculation of Couple Index (CI)

The next step is to implement the couple index method for each attribute of selected projects. The couple index is represented as the ratio of the number of participation of each attribute with the next attribute of projects to the number of projects. The mathematical description of the couple index (CI) illustrated in equation (3-4) below:

if $\{i,j\} \in N_{at}$

$CI_{a_i a_j S}$ = CI of attribute a_i and attribute a_j in selected projects

$N_S a_i a_j$ = number of selected projects which include attribute i and j

$N_S a_i$ = number of selected projects which include attribute i

then:

$$CI_{a_i a_j S} = \frac{N_S a_i a_j}{2} \left(\frac{N_S a_i + N_S a_j}{N_S a_i * N_S a_j} \right) \quad (3-4)$$

If N_{at} is assumed as the number of attributes, then each attribute will provide $N_{at}-1$ pair, therefore the N_{at} number of attributes can make the L number of pairs, which is calculated with the help of the below equation:

$$L = N_{at} * (N_{at} - 1) \quad (3-5)$$

The equation (3-5) shows the number of couple index for all attributes.

The set of CI of selected projects are collected in below N_{at} -to- N_{at} matrix:

$$CI_{a_i a_j} S = \begin{bmatrix} CI_{a_1 a_1} S & CI_{a_1 a_2} S & \dots & CI_{a_1 a_{N_{at}}} S \\ CI_{a_2 a_1} S & CI_{a_2 a_2} S & \dots & CI_{a_2 a_{N_{at}}} S \\ \dots & \dots & \dots & \dots \\ CI_{a_{N_{at}} a_1} S & CI_{a_{N_{at}} a_2} S & \dots & CI_{a_{N_{at}} a_{N_{at}}} S \end{bmatrix} \quad (3-6)$$

3.4. Calculation of Accompany Index (AI)

Once the couple index is calculated for each pair of attributes, the next step is to calculate the Accompany Index. Accompany Index of attributes is the sum of the couple index of each attribute. Therefore, the Accompany Index includes the number of attributes. From the mathematical point of view, the Accompany Index, AI, is described in equation (3-7) as below:

$$AI_{a_i} S = \frac{\left(\sum_{p=1}^{n=N_{ctg}} Max_{ctg_p a_i} S \right) - 1}{N_{ctg} - 1} \quad (3-7)$$

$$\begin{cases} AI_{a_i} S = AI \text{ value of attribute } i \text{ in selected projects} \\ \text{if there are } N_{ctg} \text{ number of categories of the attributes} \\ p \in N_{ctg} \end{cases}$$

therefore

$$Max_{ctg_p a_i} S \text{ (max CI value of } a_i \text{ in the category } p \text{ of selected projects)} = Max (CI_{a_p a_i} S)$$

$$AIS = [AI_1 S \quad AI_2 S \quad \dots \quad AI_{N_{at}} S] \quad (3-8)$$

Equation (3-8) gives the AI values of selected projects.

The Accompany Index (AI) and Couple Index (CI) have ranges between zero and one. The cases in which AI and CI values are equal to one or near to one does not mean that the attribute has potential influence on considering projects as high effectiveness attributes for projects profitability. These results should be calculated and examined for three sets of selected, unselected and all projects.

3.5. Interpreting The Final Results

The outcome of AI results of three project sets is equal to three rows labeling of projects kind as selected, unselected and all projects and m number of the column, which represents m number of attributes. There are two essential terminologies, which are called the distance ratio and ribbon width size in this research. The distance ratio is the ratio of the smallest distance value of AI over the median distance value of three sets of selected, unselected and all projects' AI values for each attribute. The ribbon width size is the value of the greatest distance between three values of each attribute AI.

The mathematical definitions are provided in equation (3-9), as below:

$$\begin{cases} |AI_{a_i}S - AI_{a_i}U| = Di_{SU}a_i \\ |AI_{a_i}S - AI_{a_i}A| = Di_{SA}a_i \\ |AI_{a_i}A - AI_{a_i}U| = Di_{AU}a_i \end{cases} \quad (3-9)$$

Where the $Di_{SU}a_i, Di_{SA}a_i, Di_{AU}a_i$ are same as:

$$\begin{cases} Di_{SU}a_i = \text{Distance between } AI_{a_i}U \text{ and } AI_{a_i}S \\ Di_{SA}a_i = \text{Distance between } AI_{a_i}A \text{ and } AI_{a_i}S \\ Di_{AU}a_i = \text{Distance between } AI_{a_i}U \text{ and } AI_{a_i}A \end{cases} \quad (3-10)$$

The distance ratio of attribute i is shown as DR_{a_i} and calculating with:

$$DR_{a_i} = \frac{MIN(Di_{SU}a_i, Di_{SA}a_i, Di_{AU}a_i)}{MAX(Di_{SU}a_i, Di_{SA}a_i, Di_{AU}a_i) - MIN(Di_{SU}a_i, Di_{SA}a_i, Di_{AU}a_i)} \quad (3-11)$$

The ribbon width represents the maximum value between the “AI”s of attribute a_i in selected, unselected, and all projects, which can take a value between zero and one only. The ribbon width calculation is shown in equation (3-12), as below:

$$RW_{a_i} = \frac{Di_{SU}a_i + Di_{SA}a_i + Di_{AU}a_i}{2} \quad (3-12)$$

In this research, the analysis process is implemented by considering the position of AIS, AIU, AIA , distance ratio, and ribbon width size.

After calculating the correlation coefficients of “Accompany Indexes” of selected, unselected, and all project, the next step is to find out and understand which of the three possible cases displayed in Figure 3.5 can happen.

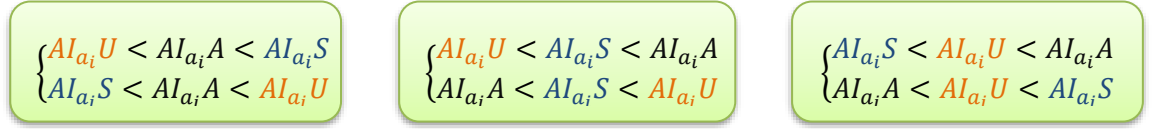


Figure 3.5: AI values arrangements

Figure 3.5 shows the three possible cases for three sets of AI values.

The max distance between $AI_{a_i}S$ and $AI_{a_i}U$ ($Di_{SU}a_i$) in category p of attribute a_i with the distance ratio smaller than as 0.25 is a sign of high potential attribute existing in the projects.

$$\left\{ \begin{array}{l} \text{Max} (Di_{SU}a_i, Di_{SU}a_j, \dots) \\ \{a_i, a_j, \dots\} \in Ctg_p (p \in N_{cat}) \\ DR_{a_i} \leq 0.25 \end{array} \right. \quad (3-13)$$

The difference between $AI_{a_i}S$ and $AI_{a_i}U$ gives a positive or negative value. The negative value is the sign of down direction and positive value is the sign of up direction. Up direction is meaning to increase the projects that included attribute a_i , and down direction is meaning to decrease the projects included attribute a_i .

$$\left\{ \begin{array}{ll} AI_{a_i}S - AI_{a_i}U > 0, & \text{The direction is upside} \\ AI_{a_i}S - AI_{a_i}U < 0, & \text{The direction is downside} \end{array} \right. \quad (3-14)$$

If $AI_{a_i}U < AI_{a_i}A < AI_{a_i}S$ or $AI_{a_i}S < AI_{a_i}A < AI_{a_i}U$ and $DR_{a_i} \leq 0.25$, and $AI_{a_i}A$ be a values close to $AI_{a_i}S$, it means that all projects are satisfied with having attribute i and the company strategy is suitable. If the $AI_{a_i}A$ be close to $AI_{a_i}U$ then the company management should change the strategy in regards of considering the attribute i . The cases discussed with more details hereafter:

3.5.1. Case Number 1

In the first case, $AI_{a_i}A$ is the median value between the $AI_{a_i}S$ value and $AI_{a_i}U$. After that, it is necessary to consider two different distance ratios that each one will address separate outcome as result. Figure 3.6 illustrates the algorithm of case number 1:

$$\begin{cases} AI_{a_i}S < AI_{a_i}A < AI_{a_i}U \\ AI_{a_i}U < AI_{a_i}A < AI_{a_i}S \end{cases} \quad (3-15)$$

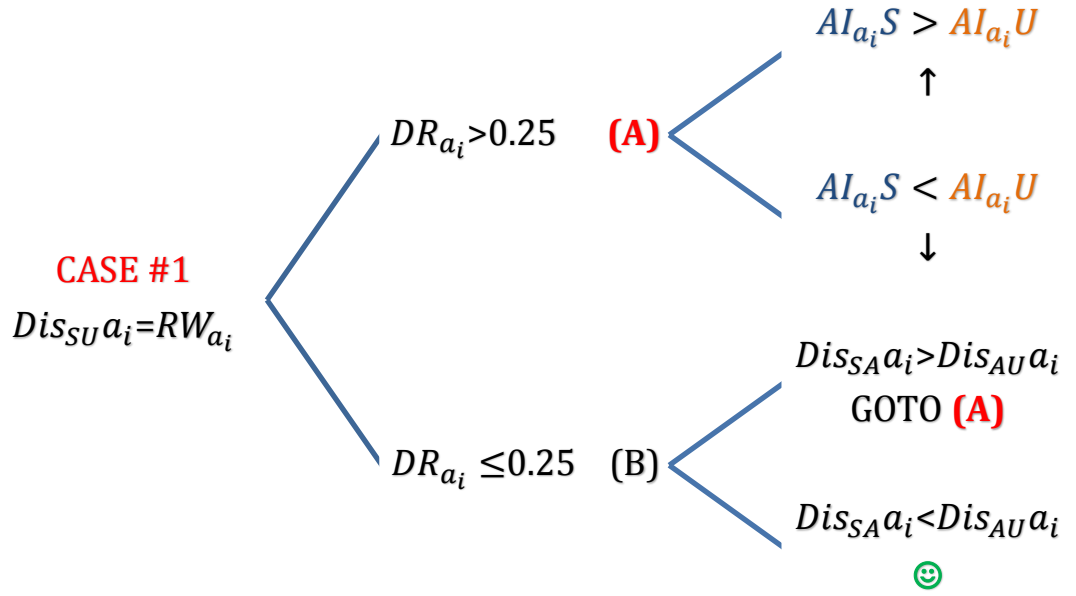


Figure 3.6: Algorithm for case number 1

Figure 3.6 is the algorithm to check which attribute matches the conditions of case number 1. Case number 1's outcome has clear and transparent result if compared with the other two cases, in which the value of AIA is not located between two other values.

If the three below conditions declared in Equation (3-17) happen together, it is a sign that the projects are not in line of high profitable attribute. Therefore, the management of the company should follow the direction of increasing or decreasing effectiveness attributes according to the result of the AIM method. The mathematical expression of this case is given in equation (3-16), as below:

$$\left\{ \begin{array}{l} AI_{a_i}S < AI_{a_i}A < AI_{a_i}U \\ AI_{a_i}U < AI_{a_i}A < AI_{a_i}S \\ Di_{SA}a_i > Di_{AU}a_i \\ DR_{a_i} \leq 0.25 \end{array} \right. \quad (3-16)$$

If equation (3-16) conditions occur, it indicates that the attributes of the selected projects are very important. The company management should adopt changes according to the directions of the selected project attribute.

If the three below conditions declared in Equation (3-18) happen together, it is a sign that the projects are satisfied for high profitability projects. The mathematical expression of this case is given in equation (3-17), as below:

$$\left\{ \begin{array}{l} AI_{a_i}S < AI_{a_i}A < AI_{a_i}U \\ AI_{a_i}U < AI_{a_i}A < AI_{a_i}S \\ Di_{SA}a_i < Di_{AU}a_i \\ DR_{a_i} \leq 0.25 \end{array} \right. \quad (3-17)$$

If equation (3-17) conditions occur, it indicates that the attributes of the selected projects are very important and projects are in the direction of importance attributes and profitable projects. There is no requirement for changes in the company strategy.

3.5.2. Case Number 2

If the three below conditions happen together, it is a sign that, the projects are satisfied and should go straightforwardly with the same plan and strategy. However, the attribute, which filtered from unselected projects, are important and highlighted. The mathematical expression of this case is given in equation (3-18), as below:

$$\left\{ \begin{array}{l} AI_{a_i}A < AI_{a_i}S < AI_{a_i}U \\ AI_{a_i}U < AI_{a_i}S < AI_{a_i}A \\ Di_{SA}a_i < Di_{SU}a_i \\ DR_{a_i} \leq 0.25 \end{array} \right. \quad (3-18)$$

If equation (3-18) conditions occur, it indicates that the attributes of the selected projects are very important and projects are satisfied with considering or ignoring these, important attributes. There is no requirement for changes.

If the three below conditions happen together, it is a sign that, selected projects attribute are not suitable for filtering the high-profit projects attribute. The mathematical shape of this case illustrated in equation (3-19) as below:

$$\left\{ \begin{array}{l} AI_{a_i}A < AI_{a_i}S < AI_{a_i}U \\ AI_{a_i}U < AI_{a_i}S < AI_{a_i}A \\ Di_{SA}a_i > Di_{SU}a_i \\ Di_{SA}a_i < Di_{SU}a_i, DR_{a_i} > 0.25 \end{array} \right. \quad (3-19)$$

If equation (3-19) conditions occur, it indicates that the attributes of the selected projects cannot be a high importance factor for filtering the projects. There is no requirement for changes by considering selected projects attribute. The algorithm of case number 2 is illustrated in Figure 3.7 in the hierarchy diagram, which includes all possible items for case, number two:

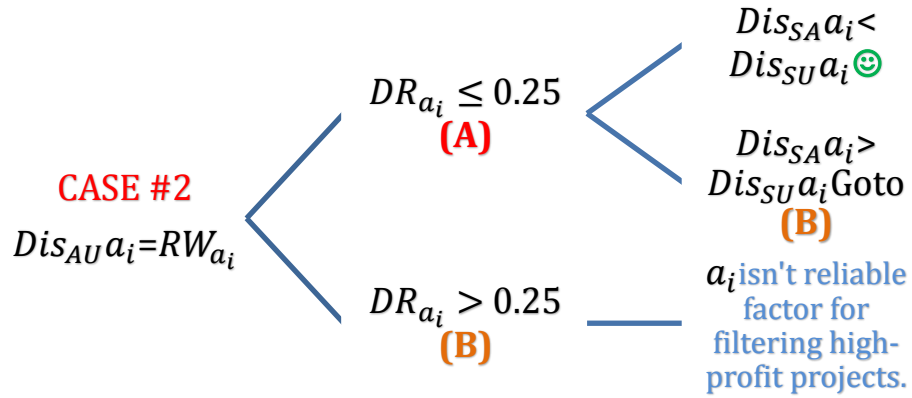


Figure 3.7: Hierarchy diagram for case number two

Figure 3.7 is the algorithm for case number 2, which analyzes and filters the attribute. It is clear in the hierarchy diagram that there are only two outcomes. First, maybe all projects already have the attribute. Therefore, there is no needs to do any changes in the aspect of this attribute in the company strategy. The second outcome of

case number 2 tells that maybe the attribute is not a reliable factor for filtering high-profit projects at all.

3.5.3. Case Number 3

If the three below conditions declared in Equation (3-20) happen together, it is a sign that, the projects are total not satisfactory. The company management needs to do changes by considering or ignoring the selected attribute. The direction of changes should be according to the direction of increasing or decreasing high potential attributes. Equation (3-20) is mathematical expression of this case:

$$\begin{cases} AI_{a_i}S < AI_{a_i}U < AI_{a_i}A \text{ or } AI_{a_i}A < AI_{a_i}U < AI_{a_i}S \\ Di_{AU}a_i < Di_{SU}a_i, DR_{a_i} \leq 0.25 \end{cases} \quad (3-20)$$

If equation (3-20) conditions occur, it indicates that the selected attributes are very important. The company should adopt changes according to the directions of the attribute.

$$\begin{cases} Di_{AU}a_i > Di_{SU}a_i \\ DR_{a_i} \leq 0.25 \end{cases} \quad \text{or if} \quad \begin{cases} Di_{AU}a_i < Di_{SU}a_i \\ DR_{a_i} \geq 0.25 \end{cases} \quad (3-21)$$

If equation (3-21) conditions occur, it indicates that the selected attributes cannot be a factor for filtering high profitable projects.

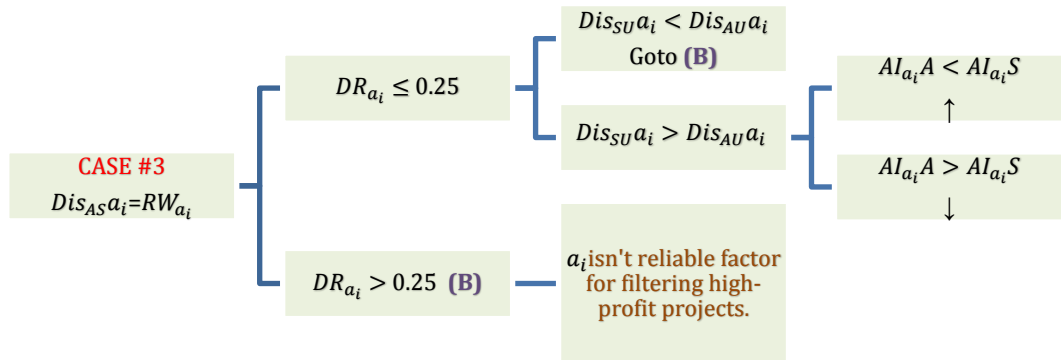


Figure 3.8: Hierarchy diagram for case number 3

Figure 3.8 shows all possible part of case number 3, in a hierarchy diagram. By implementing the algorithm, three outcomes could be considered as result of this case.

4. IMPLEMENTATION AND RESULTS

The case study is about projects from an elevator company located in Dubai, United Arab Emirates. The data are collected from the projects and contracts history of that company which gathered with the sales and marketing team. The high number of contracts and projects will give a clear result after analysis. AIM method can implement continuously each year to realize the value of changes accordingly. So the recommendation is to have a minimum of hundred different projects. For this case study, 198 projects were considered. The high variety of attributes like job site location, customer type, products and service type, etc. will define the result much more clearly.

4.1. Collecting Data and Categorizing

The project's data are divided into six different categories. The sample of prepared data and the division of categories are listed as shown in the “Appendix Data 1-8” on the last pages of this research. In the Excel sheet, the category's name is located at top of each column and each row represents the details of one project. Six categories are listed and under these categories totally 41 attributes are incorporated. The last column is placed for selecting and unselecting the project. These data are binary so if the project is selected then the cell will have a value 1. The attribute values are also binary. For instance, if the project is for full package sales of any product then the cells of the attribute of “full package” under that project will be taking the value equal to “1” otherwise the value of that cell will be “0”.

Part of the data screened in below:

Project details								sales item							
No.	Name	Profit	Cost	Quantity	Number of floors	Capacity (KG)	Time duration (Day)	Product			services				
								Full package	Parts	Spare parts	Installation	Modernization	Repairing	Maintenance	Consultancy
118	Khansaheb Construction	\$ 23,850	\$ 94,150	1	48	1600	60	✓			✓				
119	Khansaheb Construction	\$ 9,030	\$ 23,307	1	4	800	25	✓			✓				
120	Khansaheb Construction	\$ 12,711	\$ 28,322	1	4	2000	25	✓			✓				
121	Al Sakher Contracting	\$ 36,460	\$ 108,648	6	2	630	20	✓			✓				
122	Al Sakher Contracting	\$ 2,391	\$ 4,130	8	2	450	12							✓	
123	Al Sakher Contracting	\$ 10,180	\$ 33,820	4	8	800	10			✓		✓			
124	Sarah Building Contracting	\$ 9,929	\$ 16,702	1	2	450	20	✓			✓				
125	Sarah Building Contracting	\$ 1,663	\$ 2,337	4	2	550	10						✓		
126	Sarah Building Contracting	\$ 4,496	\$ 15,504	2	4	630	8			✓		✓			
127	Al Ishrak Contracting	\$ 10,073	\$ 22,535	1	3	1000	20	✓			✓				
128	Al Ishrak Contracting	\$ 25,200	\$ 67,192	2	2	1000	40	✓			✓				

Figure 4.1: Sample of projects data for analyzing process

Figure 4.1 displays a part of the data arrangement in an excel sheet for analysis. From left to right, in order, there are project number, name, profit amount for each project, the cost for the same projects, the number of products, number of floors of building, capacity of elevator, escalator, or traveller, needed time for executing the whole projects, product or service value and type. Each cell marked with a tick sign has a value of “1” for that cell and the empty cells have a value of “0”.

- The total number of projects: 198
- Total cost: \$ 9,384,513
- Total profit: \$ 2,873,725
- Location of projects: All of UAE
- Products: Elevator, Escalator, Travellator

4.2. Modeling an Integer Programming

The next step is to find out the best and high profit projects for a fixed cost or for a fixed duration and time. To filter high profitable projects from the project pool, the integer programming (IP) model used to find out the projects with the objective of maximization of profits.

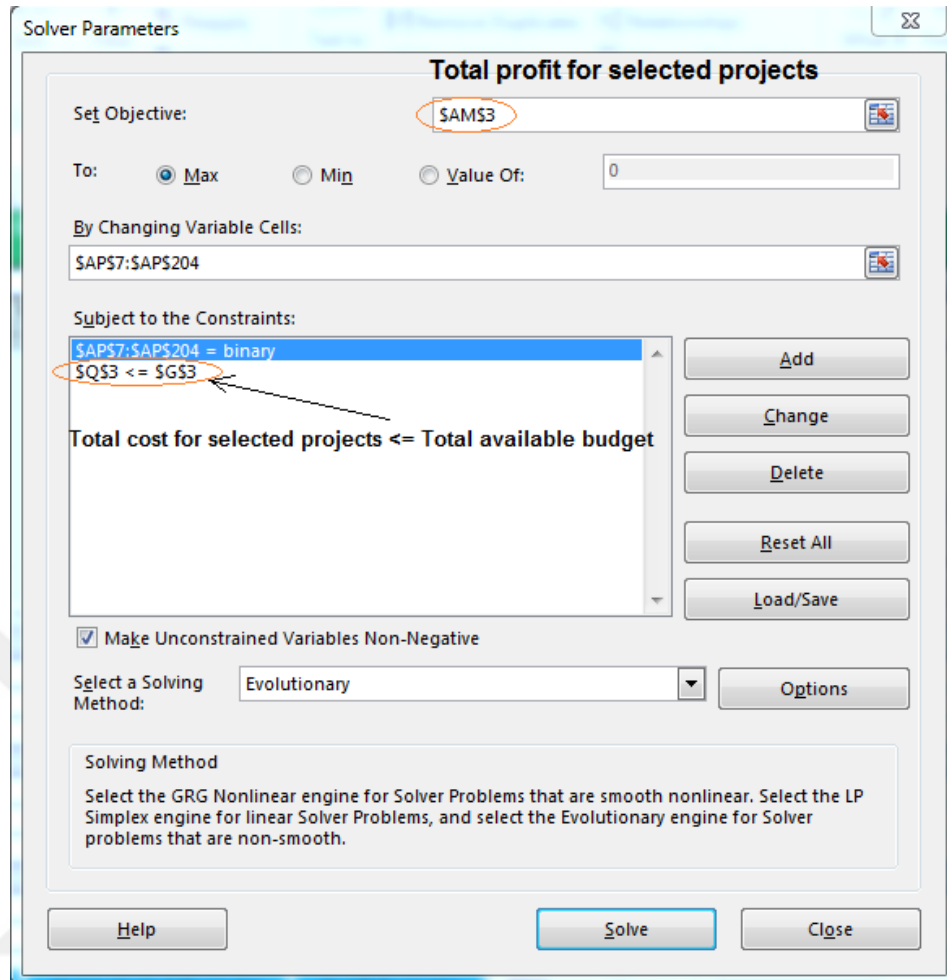


Figure 4.2: IP modeling for highly profitable projects

Figure 4.2 is the solver interface for modeling an integer program. The “AM3” cell represented the summation of the total profit of selected projects, which is in the “set objective” part of the solver targeted to maximizing. The changing variable cells are from “AP7” until “AP204”.

The constraint in Figure 4.2 is two and it is the budget or time duration with considering the changing variable in cells “AP7-AP204” just can take the binary value which the one meaning the project selected or zero which means the project not selected. The budget cell is “G3” and for this case study, it assumed as two million US dollars. The cell “Q3” is the summation of all costs related to the selected projects. By selecting an evolutionary solving method from the options, and pressing the solve button the result will come out.

The result is not a fixed case and will change after pressing again the “solve” button but the value of changing profit goes to a very small range to find the optimized answer. The results of IP modeling transferred below:

Table 4-1: The IP modeling result

Total number of selected projects	79
Total profits of selected projects	\$ 1,043,645
Total cost of selected projects	\$ 1,998,809

Table 4-1 shows that all constraints are satisfied. The total profit maximized for the cost of selected projects. In addition, the cost amount is less than two million, which in the first modeling assumed for a fixed budget of the business.

4.3. *CI* and *AI* Calculation for Data Sets

Now, there are three kinds of data sets available on the table for analyzing process. Selected projects, unselected projects, and all projects.

4.3.1. *CI* and *AI* Calculation for Selected Projects

For finding high potential attribute to getting a maximum profit, the calculation of thirty-three attributes considered, including the type of product and services, project types, products name, customer preference and marketing type. To finding the *CI* of thirty-three attributes, will giving thirty-three rows to thirty- three columns table, which has one thousand eighty nine cells.

Each element calculation is as the following principle, which the example illustrates in bellow:

$$N_S a_4 a_1 = 43$$

$$N_S a_4 = 44$$

$$N_S a_1 = 59$$

$$CI_{4,1}S = \frac{N_S a_4 a_1}{2} \left(\frac{N_S a_4 + N_S a_1}{N_S a_4 * N_S a_1} \right)$$

$$CI_{4,1}S = \frac{43}{2} \left(\frac{44 + 59}{44 * 59} \right) = 0.853$$

Table 4-2: CI calculation of attributes in data set of selected projects

Couple Index Matrix for Selected Projects CI_{ijS}	Full package	Parts	Spare parts	Installation	Modernization	Repairing	Maintenance	Consultancy
Full package	1			0.853				
Parts		1			0.375	0.750		
Spare parts			1		0.350		0.554	
Installation	0.853			1				
Modernization		0.375	0.350		1			
Repairing		0.750				1		
Maintenance			0.554				1	
Consultancy								

Table 4-2 is part of the couple index matrix for the selected projects' data set. The calculation of value in row number four and column number one explained above. The same calculation implemented in all cells of this matrix. The cells without any value represented zero value, which it is meaning the attributes in that points do not have any relation with each other.

There are 33 attributes. By the help of permutation formula, in which the ordering does not matter, the number of pair for the 33 attributes will constitute 528 CI values, which could be calculated with the combination formula as below:

$$C_{(n,r)} = \frac{n!}{r!(n-r)!} \quad (4-1)$$

$$= \frac{33!}{2!(33-2)!} = \frac{33!}{2!(31)!} = \frac{32 * 33}{2} = 528$$

The CI matrix for selected projects is embedded in the appendix (CIS TABLE) at end of this research. Once the CI for each attribute is calculated for each attribute, there are 32 CI values for each attribute, the remaining single one shows the couple index between the same attributes. The average of maximum CI of attributes in categories is represented as AI of that attribute.

The AI of the selected project could be shown as a matrix with one row and n columns, where n is the number of attributes in analyzing the process. The below equation shows the accompany index of selected projects:

$$AIS = [AI_1S \quad AI_2S \quad \dots \quad AI_{N_{at}}S] \quad (4-2)$$

The " i " is a random number from one to N_{at} which N_{at} represents the number of total attributes on the data sets, which are considered for analyzing process. In this case study, the AI of the selected project is a *matrix* ($1 * 33$). The CI and AI matrixes for selected projects embedded in appendixes at the end page of this research.

$$AI_{a_i}S = \frac{\left(\sum_{p=1}^{n=N_{cat}} Max_{Ctg_p a_1} S \right) - 1}{N_{cat} - 1} \quad (4-3)$$

For instance, the $AI_{a_i}S$ value calculation is as bellow:

$$\begin{aligned} N_{ctg} = 6 \text{ therefore } \implies AI_{a_1}S &= \frac{\left(\sum_{p=1}^6 Max_{Ctg_p a_1} S \right) - 1}{6 - 1} \\ AI_{a_1}S &= \frac{1 + 0.853 + 0.651 + 0.878 + 0.674 + 0.853 - 1}{5} = 0.782 \end{aligned}$$

4.3.2. CI and AI Calculation for Unselected Projects

To calculate the CI of unselected projects, the same procedure as the finding the CI of selected projects should follow up. The calculation of a value of CIU elements given in the following example:

$$N_U a_4 a_1 = 94$$

$$N_U a_4 = 95$$

$$N_U a_1 = 110$$

$$CI_{4,1}U = \frac{N_U a_4 a_1}{2} \left(\frac{N_U a_4 + N_U a_1}{N_U a_4 * N_U a_1} \right) \quad CI_{4,1}U = \frac{94}{2} \left(\frac{95 + 110}{95 * 110} \right) = 0.922$$

Table 4-3: Part of CI matrix for unselected projects

Couple Index Matrix for Unselected Projects $CI_{ij}U$	Full package	Parts	Spare parts	Installation	Modernization	Repairing	Maintenance	Consultancy
Full package	1			0.922				
Parts		1			0.250	0.875		
Spare parts			1		0.750		0.625	
Installation	0.922			1				
Modernization		0.250	0.750		1			
Repairing		0.875				1		
Maintenance			0.625				1	
Consultancy								

Table 4-3 is part of the couple index matrix for unselected projects data set. The calculation of value in row number four and column number one is explained above. The same calculation implemented in all cells of this matrix.

$$AIU = [AI_1U \quad AI_2U \quad \dots \quad AI_{N_{at}}U] \quad (4-4)$$

To find the AI_iU in the unselected projects, should consider the below formula which the $(Ctg_p a_i)$ are evaluating in the same data of unselected projects. Therefore, by this consideration the calculation will be as follow:

$$AI_{a_i}U = \frac{\left(\sum_{p=1}^{n=N_{cat}} Max_{Ctg_p a_i} U \right) - 1}{N_{cat} - 1} \quad (4-5)$$

For instance, the $AI_{a_1}U$ value calculation is as below:

$$N_{ctg} = 6 \text{ therefore:}$$

$$AI_{a_1}U = \frac{\left(\sum_{p=1}^6 Max_{Ctg_p a_1} U \right) - 1}{6 - 1}$$

$$AI_{a_1}U = \frac{1 + 0.922 + 0.632 + 0.913 + 0.718 + 0.830 - 1}{5} = 0.803$$

Table 4-4: Part of AI value

<i>AI</i> <i>Accompany Index</i>	Full package	Parts	Spare parts	Installation
<i>AIS</i>	0.782	0.510	0.593	0.710
<i>AIU</i>	0.803	0.487	0.518	0.738
<i>AIA</i>	0.789	0.483	0.539	0.726

Table 4-4 shows some AI values of three sets of projects. To have an example, the AI value of selected projects for attribute number one (Full package) calculated above.

4.3.3. *CI* and *AI* Calculation for All Projects

Again, the same *CI* calculation for selected and unselected projects should implemented. Just, in this case, the data sets included all projects. Therefore, the calculation will be like as below process:

$$N_A a_4 a_1 = 137$$

$$N_A a_4 = 139$$

$$N_A a_1 = 169$$

$$CI_{4,1}A = \frac{N_A a_4 a_1}{2} \left(\frac{N_A a_4 + N_A a_1}{N_A a_4 * N_A a_1} \right)$$

$$CI_{4,1}A = \frac{137}{2} \left(\frac{139 + 169}{139 * 169} \right) = 0.898$$

Table 4-5: Part of *CI* matrix for all projects

Couple Index Matrix for All Projects $CI_{ij}A$	Full package	Parts	Spare parts	Installation	Modernization	Repairing	Maintenance	Consultancy
Full package	1			0.898				
Parts		1			0.292	0.804		
Spare parts			1		0.556		0.456	
Installation	0.898			1				
Modernization		0.292	0.556		1			
Repairing		0.804				1		
Maintenance			0.456				1	
Consultancy								

Table 4-5 is part of the couple index matrix for all project data sets. The calculation of value in row number four and column number one explained above. The same calculation implemented in all cells of this matrix.

$$AIA = [AI_1A \quad AI_2A \quad \dots \quad AI_{N_{at}}A] \quad (4-6)$$

To find the $AI_{a_i}A$ in all projects data sets should consider the below formula which the $(Cat_p a_i)$ are evaluating in the same data of all projects. Therefore, by this consideration the calculation will be as follow:

$$AI_{a_i}A = \frac{\left(\sum_{p=1}^{n=N_{cat}} Max_{Cat_p a_i} A \right) - 1}{N_{cat} - 1} \quad (4-7)$$

For instance, the $AI_{a_1}S$ value calculation is as bellow:

$$N_{ctg} = 6 \text{ therefore:}$$

$$AI_{a_1}A = \frac{\left(\sum_{p=1}^6 Max_{Cat_p a_1} A \right) - 1}{6 - 1}$$

$$AI_{a_1}A = \frac{1 + 0.898 + 0.625 + 0.894 + 0.690 + 0.838 - 1}{5} = 0.789$$

4.4. Final Result

The numeric values as result of this research are illustrated in the tables hereafter. These tables are the result values that makes it possible to analyze the outcome and compare them together. The analysis procedure in this method needs the calculation of the distance ratio and the ribbon width for all attributes and make a model that gives weight to the direction of the filtered attribute in any of the three cases, described before. Filtering the highest distance of AIS and AIU in each category one could recognize the high potential attribute if the conditions in the described cases match with that particular attribute. In this research, the highest distance between AIS and AIU shows the weight with the direction of changes. The direction of changes is equal to the sign of differences of $AI_{a_i}S$ and $AI_{a_i}U$. if the difference is negative then the direction is onto the downside otherwise the direction is to the upside.

Table 4-6: Distance, ribbon width and distance ratio values

	Full package	Parts	Spare parts	Installation	Modernization	Repairing	Maintenance	Consultancy	Villa	Houses	Complex	Car lift	Parking lift	Construction lifts, Factory
$Di_{SA}a_i$	0.007	0.027	0.054	0.016	0.098	0.036	0.103		0.024	0.017	0.112	0.506	0.506	0.021
$Di_{AU}a_i$	0.014	0.004	0.021	0.012	0.010	0.054	0.058		0.006	0.074	0.054	0.005	0.006	0.024
$Di_{SU}a_i$	0.021	0.023	0.076	0.028	0.088	0.018	0.045		0.019	0.091	0.166	0.511	0.512	0.003
RW_{a_i}	0.021	0.027	0.076	0.028	0.098	0.054	0.103		0.024	0.091	0.166	0.511	0.512	0.024
DR_{a_i}	0.52	0.2	0.39	0.76	0.11	0.5	0.78		0.32	0.23	0.48	0.01	0.01	0.15

Table 4-6 shows the distance between the accompany indexes of selected, unselected, and all projects and ribbon width and distance ratio of fourteen attributes only.

Table 4-7: Accompany index result of three sets of projects

AI Accompany Index	Full package	Parts	Spare parts	Installation	Modernization	Repairing	Maintenance	Consultancy	Villa	Houses	Complex	Car lift	Parking lift	Construction lifts, Factory
AIS	0.782	0.510	0.593	0.710	0.523	0.526	0.601		0.566	0.424	0.592			0.464
AIU	0.803	0.487	0.518	0.735	0.435	0.545	0.556		0.547	0.514	0.425	0.511	0.512	0.467
AIA	0.789	0.483	0.539	0.726	0.425	0.490	0.498		0.541	0.440	0.479	0.506	0.506	0.443

Table 4-7 shows the accompany index result of the selected, unselected, and all projects of this research.

The calculation of some values shows below. For example, the, the $(Di_{SU}a_1)$, $(Di_{SA}a_1)$ and $(Di_{AU}a_1)$ calculation show here:

$$\begin{aligned}
 Di_{SU}a_1 &= |AI_{a_1}S - AI_{a_1}U| \\
 Di_{SA}a_1 &= |AI_{a_1}S - AI_{a_1}A| \\
 Di_{AU}a_1 &= |AI_{a_1}A - AI_{a_1}U|
 \end{aligned}
 \begin{cases}
 AI_{a_1}S = 0.782 \\
 AI_{a_1}U = 0.803 \\
 AI_{a_1}A = 0.789
 \end{cases}
 \quad (4-8)$$

$$\begin{cases}
 |0.782 - 0.803| = 0.021 \\
 |0.782 - 0.789| = 0.007 \\
 |0.789 - 0.803| = 0.014
 \end{cases}$$

The distance between the accompany indexes of projects shows by equation (4-8).

By putting, the distance value in the formulas, the distance ratio and the ribbon width size could calculate as below:

$$DR_{a_1} = \frac{MIN(Di_{SU}a_1, Di_{SA}a_1, Di_{AU}a_1)}{MAX(Di_{SU}a_1, Di_{SA}a_1, Di_{AU}a_1) - MIN(Di_{SU}a_1, Di_{SA}a_1, Di_{AU}a_1)}$$

$$DR_{a_1} = \frac{0.007}{0.021 - 0.007} = 0.5$$

$$RW_{a_1} = \frac{Di_{SU}a_1 + Di_{SA}a_1 + Di_{AU}a_1}{2}$$

$$RW_{a_1} = \frac{0.021 + 0.007 + 0.014}{2} = 0.021$$

The RW_{a_1} clarifies that the position of which AI value is between others. In this example (RW_{a_1}) is equal to the value of $(Di_{SU}a_1)$. It means the highest distance is

between the *AI* values of selected and unselected projects. Therefore, the median *AI* value is the *AI* of all projects. This matter is very clear by looking at the data.

However, this kind of calculation is essential to making a model that transfers the numeric value to the drawing, indicating the directions on each attribute and marking important attributes for filtering high profitability project factors.

Table 4-8: Result indicators part one

RESULT	Full package	Parts	Spare parts	Installation	Modernization	Repairing	Maintenance	Consultancy	Villa	Houses	Complex	Car lift	Parking lift	Construction lifts, Factory
Case 01	↘		↗	↘						↗	↗	↘	↘	
Case 02						X								X
Case 03		↗			↗		X		X					

Table 4-8 is part one of the result in indicator shape. This table included the fourteen attribute analyzes. The other attributes resulting from indicators shown in the next table.

Table 4-9: Result indicators part two

RESULT	High rise	Mid rise, offices, Hotel, School	Malls & public area	Hospitals & disability	Dumbwaiter	Elevator	Escalator	Travellator	Less price	Innovation, new fixtures	Custom design	Luxury product	Speed of service	Leak of resource	Safety & quality	Site visit of sales	advertising	Previous customer	Previous projects
Case 01		↗	↗		↗		↘	↘	↗	↗	↗	↗	↗			↗		↗	↗
Case 02				X															
Case 03	X					↗								X	X				

Table 4-9 is the second part of the result in indicator shape. This table included the nineteen attribute analyzes. There are six kinds of indicators in Table 4-9. The upside green indicator means that the number of projects with having that attribute needs to

increase and there is less number of projects with that attribute in selected projects. The projects, which included attributes 2, 5, 19, 20 and 32, have to increase.

The downside red indicator is meaning exactly like the upside green indicator just in opposite direction. In this case, red downside indicator is saying that projects for car lifts, parking lifts, escalators, and travellators should not contracted in the future.

The yellow upside indicator is meaning that the number of projects having that attribute needs to increase, and already on the projects that attribute existed. This indicator filters the below attributes:

- | | |
|---------------------------------|----------------------------------|
| 1. Spare part | 4. Innovation |
| 2. Complex buildings | 5. Custom design |
| 3. Malls & public area projects | 6. Site visit for marketing type |

The yellow right side indicator is meaning that the projects are satisfied to having or not including that attribute in high profit projects. In this real case, projects with house attribute is satisfied and no need to do any changes in aspect of this attribute.

The yellow downside indicator is meaning that the number of projects having that attribute needs to decrease, and already on the projects, that attribute existed but less. This indicator filters the below attributes:

- ❖ Sale of full package item
- ❖ Installation services
- ❖ Midrise buildings
- ❖ Less price
- ❖ Luxury product
- ❖ Speed of service
- ❖ Previous projects link for marketing

The black cross indicator is telling that the profitability of projects with the selected attribute are not stable, therefore these attributes are not suitable for filtering profitable projects. The result tables with cross indicators show the attributes, which should not consider for filtering high profitable projects. These attributes listed below:

- | | | | |
|----------------|--------------|-----------------------|-----------------------|
| 1. Repairing | 2. Villa | 3. High rise building | 4. Lack of resource |
| 5. Maintenance | 6. Hospitals | 7. Constriction lifts | 8. Safety and quality |

Just two attributes did not have any indicator and it is meaning the projects with having that attribute did not exist at all in the pool of projects. For realizing the difference between AIM method and percentage methods, it is necessary to study the other method's outcome that are displayed in Table 4-10:

Table 4-10: Result of other methods

%	Full package	Parts	Spare parts	Installation	Modernization	Repairing	Maintenance	Consultancy	Villa	Houses	Complex	Car lift	Parking lift	Construction lifts, Factory
In selected projects	75%	5%	6%	56%	3%	5%	16%	0%	41%	11%	10%	0%	0%	4%
In unselected projects	92%	3%	3%	80%	3%	3%	1%	0%	24%	16%	8%	1%	1%	2%
In all projects	85%	4%	5%	70%	3%	4%	7%	0%	31%	14%	9%	1%	1%	3%
Difference (S-U)	18%	2%	3%	24%	1%	3%	16%		16%	5%	3%	1%	1%	2%
DIRECTION	↓	↑	↑	↓	↓	↑	↑		↑	↓	↑	↓	↓	↑

In Table 4-10, first row is the number of selected projects with existing of each column attributes over the number of selected projects. For instance, in the first row and first column the 75%, is found as:

$$N_S = 79, \quad N_S a_1 = 59 \quad \implies \quad \frac{N_S a_1}{N_S} = \frac{59}{79} = \%75$$

The same calculation has to be executed on the unselected projects (second row) and all projects (third row). The difference between the first row and the second row will define the value and direction of changes. In other words, the projects with the first attribute have decreased 18% of the number of projects, which included attribute one. Increasing the number of projects with having a fifth attribute is recommended by the AIM, whereas the percentage method is not recommending it. In the percentage method show, the difference decreased. There are some other different results that can be seen by comparing these two methods. If the difference percentage method with the accompany index method are compared, the result is not exactly the same, because, in this novel method implemented in this research, all attributes are analyzed while they are linked with other attributes and the results are comprehensive.

5. CONCLUSION

In this thesis, the case study was an elevator company project's history. The projects are described with 33 attributes. The profitable projects were selected with help of integer programming. The selected projects with unselected projects and all projects compared together. However, the importance of the accompany index method affected finding out the most effective attribute, which could filter the profitable projects.

As a final recommendation for this elevator company, the management has to increase sales of parts and look for projects that required elevator modernization. The product of elevators and dumbwaiters should increase. “Innovation” and “custom design” are the best factors, which help to have high profitable projects. So need to develop and focus on R&D departments. In addition, the “site visit” and “previous customers” attributes are the link of company to the clients to getting high profitable projects. So should satisfy the existing customers to have your customer as the sales team.

The Accompany Index Method (AIM) for analyzing projects could implement in any sector with fewer or more attributes. Just need to put the history of previous projects or estimated contracts to realize and filter the most profitable projects or products for sales. This novel method could extend by adding new features like as seasonal project attributes. Some products or services are seasonal and analyzing these kinds of projects should be implemented by the new technic in this method to avoid the seasonal effect on the selection of highly profitable projects.

Introducing new services or products may fire the old product forever. In this kind of situation, analyzing by this method is not suitable because for getting better results should this method apply continually every 6 months or 1 year. If the products are fired with, coming new products the case will change totally. This kind of issue should consider before applying the AIM method.

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APPENDIX (ATTRIBUTES TABLE)

Ctg_p	Category	a_i	Attributes
Ctg_1	Product type	a_1	Full package
		a_2	Parts
		a_3	Spare parts
Ctg_2	Service type	a_4	Installation
		a_5	Modernization
		a_6	Repairing
		a_7	Maintenance
		a_8	Consultancy
Ctg_3	Building type	a_9	Villa
		a_{10}	House
		a_{11}	Complex
		a_{12}	Car lift
		a_{13}	Parking lift
		a_{14}	Construction lift
		a_{15}	High-rise
		a_{16}	Mid-rise
		a_{17}	Malls and public area
		a_{18}	Hospital and disability
Ctg_4	Product	a_{19}	Dumbwaiter
		a_{20}	Elevator
		a_{21}	Escalator
Ctg_5	Customer preferences	a_{22}	Travellator
		a_{23}	Less price
		a_{24}	Innovation
		a_{25}	Custom design
		a_{26}	Luxury
		a_{27}	Speed of services
		a_{28}	Lack of resource
Ctg_6	Marketing method	a_{29}	Safety and quality
		a_{30}	Site visit
		a_{31}	Advertisement
		a_{32}	Previous customer
		a_{33}	Previous project

APPENDIX (DATA 1)

No.	Name	Profit	Cost	Quantity	Number of floors	Capacity (KG)	Time duration (Day)	Product			services				Residential			
								Full package	Parts	Spare parts	Installation	Modernization	Repairing	Maintenance	Consultancy	Villa	Houses	Complex
1	Cubics design	\$ 1,748	\$ 11,839	1	2	350	10	✓			✓							
2	AlJawal Contracting	\$ 11,578	\$ 19,673	1	4	450	30	✓			✓							
3	Saeed Mohammad Proj.	\$ 15,026	\$ 89,594	2	7	550	40	✓			✓						✓	
4	Chicago constriction	\$ 8,385	\$ 29,115	1	4	1600	30	✓			✓							
5	Al Suwaidi contracting	\$ 5,712	\$ 16,027	1	3	680	30	✓			✓						✓	
6	Al Huzafa contracting	\$ 5,596	\$ 18,589	1	4	680	30	✓			✓						✓	
7	First art contracting	\$ 8,087	\$ 58,489	1	3	400	30	✓								✓		
8	Al Rams prime constriction	\$ 9,221	\$ 27,464	1	10	800	38	✓									✓	
9	Gover contracting	\$ 10,287	\$ 19,605	1	4	450	30	✓			✓							
10	Gover contracting	\$ 14,750	\$ 60,250	2	2	1000	50	✓			✓							
11	QCD contracting	\$ 8,547	\$ 21,345	1	3	400	30	✓			✓						✓	
12	QCD contracting	\$ 7,939	\$ 8,365	1	3	50	15	✓			✓						✓	
13	QCD contracting	\$ 5,603	\$ 17,495	1	2	400	25	✓			✓						✓	
14	Al Madar engineering	\$ 12,740	\$ 72,858	2	15	1000	50	✓			✓							
15	Al Rossokh contracting	\$ 12,948	\$ 25,639	2	3	500	25	✓			✓					✓		
16	Cham'inar	\$ 3,691	\$ 4,461	10	8	800	12						✓					✓
17	DCE contracting	\$ 73,840	\$ 162,573	6	9	630	45	✓			✓							
18	DCE contracting	\$ 35,994	\$ 88,734	3	10	630	45	✓			✓							
19	DCE contracting	\$ 10,172	\$ 25,154	1	2	750	20	✓			✓							
20	DCE contracting	\$ 10,628	\$ 26,057	1	3	750	10	✓			✓							
21	DCE contracting	\$ 26,269	\$ 79,709	2	12	900	30	✓			✓							
22	DCE contracting	\$ 29,138	\$ 44,231	2	4	900	20	✓			✓							
23	DCE contracting	\$ 20,162	\$ 64,077	2	12	900	30	✓			✓							
24	DCE contracting	\$ 30,738	\$ 42,631	2	2	900	20	✓			✓							
25	DCE contracting	\$ 13,136	\$ 23,549	1	4	900	20	✓			✓							
26	AIA contracting	\$ 17,531	\$ 72,143	3	7	630	45	✓			✓						✓	
27	Al Kaitoob contracting	\$ 71,189	\$ 686,963	18	15	1000	150	✓			✓						✓	
28	Al Kaitoob contracting	\$ 7,814	\$ 114,468	3	15	800	50	✓			✓						✓	
29	Al Kaitoob contracting	\$ 38,868	\$ 140,479	3	15	1350	60	✓			✓							
30	Ideal system contracting	\$ 15,190	\$ 67,418	2	10	1000	40	✓			✓						✓	
31	Intermass engineering	\$ 13,396	\$ 31,441	1	6	1275	10	✓			✓							
32	Intermass engineering	\$ 7,524	\$ 34,596	1	6	1600	10	✓			✓							
33	Intermass engineering	\$ 10,653	\$ 27,391	1	2	1275	10	✓			✓							
34	Intermass engineering	\$ 5,870	\$ 51,739	1	11	1275	20	✓			✓							
35	Intermass engineering	\$ 6,417	\$ 48,475	1	11	1600	20	✓			✓							
36	Alice building contracting	\$ 8,443	\$ 17,644	1	2	400	25	✓			✓					✓		
37	Emirates European Hospital	\$ 2,471	\$ 4,866	1	6	1000	3		✓			✓						
38	Deira contracting	\$ 15,892	\$ 19,163	1	2	400	20	✓			✓					✓		
39	LBS contracting	\$ 4,543	\$ 20,458	1	3	630	25	✓			✓					✓		
40	Al Memzar contracting	\$ 4,578	\$ 63,357	2	9	800	30	✓			✓						✓	
41	Granada Europe Const.	\$ 22,643	\$ 50,726	2	4	1050	10	✓			✓							
42	Granada Europe Const.	\$ 18,626	\$ 59,092	2	3	1600	10	✓			✓							
43	Granada Europe Const.	\$ 10,993	\$ 23,518	1	3	1050	10	✓			✓							
44	Qasr Al Andalos cont.	\$ 5,607	\$ 21,295	1	3	450	30	✓			✓					✓		
45	Al Yaqin contracting	\$ 11,982	\$ 40,736	2	3	450	30	✓								✓		
46	Al Shafar National Cont.	\$ 14,997	\$ 50,221	2	5	1000	30	✓			✓						✓	
47	SOBHA LLC	\$ 44,267	\$ 69,864	4	2	400	25	✓			✓					✓		
48	SOBHA LLC	\$ 44,267	\$ 69,864	4	2	400	25	✓			✓					✓		
49	SOBHA LLC	\$ 49,537	\$ 72,202	4	2	630	25	✓			✓					✓		
50	SOBHA LLC	\$ 41,197	\$ 54,998	3	2	630	25	✓			✓					✓		

APPENDIX (DATA 2)

No.	Name	Profit	Cost	Quantity	Number of floors	Capacity (KG)	Time duration (Day)	Product			services				Residential		
								Full package	Parts	Spare parts	Installation	Modernization	Repairing	Maintenance	Consultancy	Villa	Houses
50	SOBHA LLC	\$ 41,197	\$ 54,998	3	2	630	25	✓				✓					
51	Alice building contracting	\$ 5,566	\$ 18,619	1	2	400	25	✓				✓					
52	Al Hamad contracting	\$ 8,761	\$ 19,772	1	3	450	25	✓				✓					
53	Al Zajil Building Cont.	\$ 6,407	\$ 23,485	1	5	800	30	✓				✓				✓	
54	City Creek Constriction	\$ 17,153	\$ 48,608	2	6	800	20	✓				✓					
55	City Creek Constriction	\$ 11,619	\$ 26,696	1	7	1000	20	✓				✓					
56	Skyline contracting	\$ 11,549	\$ 22,418	1	2	450	35	✓				✓				✓	
57	Top Speed Contracting	\$ 9,810	\$ 21,440	1	4	630	15	✓									✓
58	Top Speed Contracting	\$ 9,589	\$ 20,302	1	4	630	15	✓									✓
59	Yas Contracting	\$ 7,489	\$ 19,142	1	3	450	25	✓								✓	
60	AGC Building Contracting	\$ 7,549	\$ 18,266	1	2	450	25	✓								✓	
61	Span Steel Constriction	\$ 13,721	\$ 25,138	1	3	1600	35	✓									
62	Al Warraq Building Cont.	\$ 5,852	\$ 19,963	1	3	630	30	✓									
63	Yas Contracting	\$ 6,479	\$ 19,336	1	2	450	25	✓								✓	
64	ASNC	\$ 2,266	\$ 12,334	2	2	300	10	✓									
65	Constriction Consortium	\$ 9,147	\$ 20,745	1	3	800	25	✓									
66	Armada Contracting	\$ 9,582	\$ 20,310	1	4	450	20	✓									✓
67	Armada Contracting	\$ 5,518	\$ 10,243	1	4	50	10	✓									
68	Intermass engineering	\$ 87,913	\$ 202,304	6	14	800	50	✓									
69	Intermass engineering	\$ 55,630	\$ 142,197	4	15	800	50	✓									
70	Intermass engineering	\$ 25,681	\$ 30,025	1	6	2000	20	✓									
71	Intermass engineering	\$ 17,524	\$ 25,954	1	6	1000	20	✓									
72	VICC	\$ 16,024	\$ 73,650	2	14	1000	50	✓									
73	Sunshine Oasis Cont.	\$ 7,310	\$ 17,690	1	2	450	25	✓								✓	
74	City Sky Contracting	\$ 14,764	\$ 17,301	1	2	630	25	✓								✓	
75	ASGC	\$ 43,127	\$ 96,004	4	5	1050	20	✓									
76	ASGC	\$ 17,074	\$ 49,230	2	5	1050	20	✓									
77	Granada Europe Const.	\$ 19,917	\$ 94,214	3	9	1000	25	✓									
78	Granada Europe Const.	\$ 5,053	\$ 33,805	1	9	1250	25	✓									✓
79	Dubai Sky Contracting	\$ 9,860	\$ 17,043	1	2	630	25	✓								✓	
80	Real House Contracting	\$ 9,601	\$ 17,029	1	2	630	25	✓								✓	
81	Ocean Star Constriction	\$ 10,038	\$ 18,494	1	3	630	25	✓								✓	
82	VICC	\$ 21,860	\$ 56,140	3	2	1000	20	✓									
83	VICC	\$ 4,985	\$ 11,515	1	3	100	10	✓									
84	Rotaj Contracting	\$ 8,859	\$ 17,772	1	2	450	25	✓								✓	
85	Rotaj Contracting	\$ 3,261	\$ 3,261	8	3	450	12							✓		✓	
86	Advance contracting	\$ 12,619	\$ 21,348	1	2	450	20	✓								✓	
87	Advance contracting	\$ 4,600	\$ 18,000	2	6	630	10		✓			✓					✓
88	Advance contracting	\$ 4,674	\$ 3,478	10	3	450	12							✓		✓	
89	ASCA Building Contracting	\$ 31,071	\$ 66,755	3	4	1000	25	✓				✓					
90	Al Huzaifa contracting	\$ 4,359	\$ 18,195	1	3	630	20	✓				✓					
91	Orascom Contracting	\$ 72,001	\$ 107,347	4	2	2000	10	✓				✓					
92	Orascom Contracting	\$ 34,408	\$ 52,549	2	2	2000	10	✓				✓					
93	Orascom Contracting	\$ 40,480	\$ 183,520	4	2	4000	30	✓				✓					
94	Ashiyana Contracting	\$ 4,813	\$ 10,132	1	4	100	20	✓				✓					
95	Granada Europe Const.	\$ 24,197	\$ 106,238	3	14	1000	25	✓				✓					✓
96	Granada Europe Const.	\$ 6,888	\$ 37,949	1	14	1250	25	✓				✓					✓
97	Granada Europe Const.	\$ 4,885	\$ 4,898	6	14	800	12							✓			✓
98	Bhatia General Cont.	\$ 49,097	\$ 108,512	4	3	2000	30	✓				✓					
99	Bhatia General Cont.	\$ 9,181	\$ 27,504	1	2	2000	10	✓				✓					
100	Bhatia General Cont.	\$ 17,728	\$ 69,229	2	4	3000	10	✓				✓					

APPENDIX (DATA 3)

No.	Name	Profit	Cost	Quantity	Number of floors	Capacity (KG)	Time duration (Day)	Product			services					Residential		
								Full package	Parts	Spare parts	Installation	Modernization	Repairing	Maintenance	Consultancy	Villa	Houses	Complex
101	Armada Contracting	\$ 53,539	\$ 142,113	6	5	1000	30	✓			✓							
102	City Space Contracting	\$ 34,904	\$ 54,770	2	2	2000	30	✓			✓							
103	ASGC	\$ 5,978	\$ 3,804	12	2	450	12							✓		✓		
104	Khoory Hill Building & Cont.	\$ 5,567	\$ 43,346	1	2	3000	30	✓			✓							
105	Emirates Sands Contracting	\$ 7,747	\$ 19,155	1	3	450	25	✓			✓						✓	
106	Emirates Sands Contracting	\$ 9,743	\$ 19,605	1	3	630	25	✓			✓					✓		
107	Emirates Sands Contracting	\$ 8,084	\$ 17,731	1	2	450	20	✓			✓					✓		
108	Excel Engendering & Cont.	\$ 8,917	\$ 17,985	1	3	400	25	✓			✓					✓		
109	Pantheon Group	\$ 15,461	\$ 11,170	4	7	1000	20				✓						✓	
110	Pantheon Group	\$ 1,738	\$ 1,659	1	2	630	20				✓						✓	
111	Al Ishrak Contracting	\$ 10,437	\$ 59,128	2	7	1000	15	✓			✓						✓	
112	Al Ishrak Contracting	\$ 4,833	\$ 28,591	1	7	1000	15	✓			✓						✓	
113	Projeco Contracting	\$ 17,517	\$ 25,961	1	4	630	30	✓			✓					✓		
114	Moon Link Contracting	\$ 2,242	\$ 19,497	1	5	450	30	✓			✓						✓	
115	Dream House Contracting	\$ 3,996	\$ 24,537	1	5	1000	30	✓			✓							
116	Khansaheb Constriction	\$ 42,063	\$ 392,938	5	47	1150	60	✓			✓							
117	Khansaheb Constriction	\$ 21,240	\$ 92,760	1	47	1600	60	✓			✓							
118	Khansaheb Constriction	\$ 23,850	\$ 94,150	1	48	1600	60	✓			✓							
119	Khansaheb Constriction	\$ 9,030	\$ 23,307	1	4	800	25	✓			✓					✓		
120	Khansaheb Constriction	\$ 12,711	\$ 28,322	1	4	2000	25	✓			✓					✓		
121	Al Sakher Contracting	\$ 36,460	\$ 108,648	6	2	630	20	✓			✓					✓		
122	Al Sakher Contracting	\$ 2,391	\$ 4,130	8	2	450	12							✓		✓		
123	Al Sakher Contracting	\$ 10,180	\$ 33,820	4	8	800	10			✓		✓				✓		✓
124	Sarah Building Contracting	\$ 9,929	\$ 16,702	1	2	450	20	✓			✓					✓		
125	Sarah Building Contracting	\$ 1,663	\$ 2,337	4	2	550	10						✓			✓		
126	Sarah Building Contracting	\$ 4,496	\$ 15,504	2	4	630	8			✓		✓					✓	
127	Al Ishrak Contracting	\$ 10,073	\$ 22,535	1	3	1000	20	✓			✓							
128	Al Ishrak Contracting	\$ 25,200	\$ 67,192	2	2	1000	40	✓			✓							
129	OMIS Contracting	\$ 15,891	\$ 163,457	3	28	1000	150	✓			✓							
130	OMIS Contracting	\$ 13,963	\$ 238,754	3	28	1000	150	✓			✓							
131	OMIS Contracting	\$ 14,255	\$ 60,745	1	5	3500	60	✓			✓							
132	City Sky Contracting	\$ 8,231	\$ 18,399	1	3	630	25	✓			✓					✓		
133	City Sky Contracting	\$ 3,171	\$ 9,872	1	2	50	10	✓			✓					✓		
134	City Sky Contracting	\$ 1,100	\$ 2,500	2	8	550	8		✓				✓				✓	
135	Loyal Group	\$ 8,489	\$ 18,142	1	2	800	20	✓			✓							
136	Al Manakh Building Cont.	\$ 1,760	\$ 23,240	1	5	800	30	✓			✓							
137	Al Manakh Building Cont.	\$ 5,503	\$ 17,595	1	2	450	20	✓			✓					✓		
138	Al Sakher Contracting	\$ 5,911	\$ 54,958	2	6	1150	30	✓			✓							✓
139	Al Sakher Contracting	\$ 7,093	\$ 52,689	2	6	1000	30	✓			✓							✓
140	Al Sakher Contracting	\$ 6,586	\$ 52,110	2	5	1150	30	✓			✓							✓
141	Al Sakher Contracting	\$ 3,870	\$ 14,130	4	8	800	30		✓				✓					
142	VGC Building Contracting	\$ 8,084	\$ 17,731	1	2	450	20	✓			✓						✓	
143	Orascom Contracting	\$ 28,840	\$ 123,160	4	9	1000	100	✓			✓							
144	Orascom Contracting	\$ 20,840	\$ 167,160	4	2	1200	90	✓			✓							
145	Orascom Contracting	\$ 6,100	\$ 91,900	2	2	3000	40	✓			✓							
146	Orascom Contracting	\$ 26,220	\$ 75,780	4	15	1500	40	✓			✓							
147	Alice building contracting	\$ 7,189	\$ 19,442	1	4	450	25	✓			✓						✓	
148	Alice building contracting	\$ 2,540	\$ 4,060	6	6	450	1		✓				✓					✓
149	Granada Europe Const.	\$ 6,327	\$ 39,325	1	16	1250	60	✓			✓							
150	Granada Europe Const.	\$ 11,717	\$ 85,022	2	16	1000	60	✓			✓							

APPENDIX (DATA 4)

No.	Name	Profit	Cost	Quantity	Number of floors	Capacity (KG)	Time duration (Day)	Product			services					Residential		
								Full package	Parts	Spare parts	Installation	Modernization	Repairing	Maintenance	Consultancy	Villa	Houses	Complex
151	Granada Europe Const.	\$ 13,510	\$ 82,490	2	2	1300	30	✓			✓							
152	Sterling House Building Cont.	\$ 11,979	\$ 39,652	1	3	450	25	✓			✓					✓		
153	Alice building contracting	\$ 6,494	\$ 17,963	1	3	450	25	✓			✓					✓		
154	Bhatia General Cont.	\$ 7,789	\$ 18,842	1	2	450	20	✓			✓					✓		
155	Bhatia General Cont.	\$ 4,034	\$ 10,097	1	2	50	15	✓			✓							
156	Emkaan Engineering Consult.	\$ 5,453	\$ 21,992	1	4	800	30	✓			✓						✓	
157	ASGC	\$ 6,957	\$ 12,608	1	2	100	10	✓			✓							
158	Bhatia General Cont.	\$ 10,784	\$ 31,336	1	4	1000	30	✓			✓							
159	Bhatia General Cont.	\$ 16,258	\$ 103,307	2	4	5000	30	✓			✓							
160	Transfast Building Cont.	\$ 9,066	\$ 17,564	1	2	630	20	✓			✓					✓		
161	Ocean Star Constriction	\$ 12,433	\$ 24,252	1	3	630	25	✓			✓					✓		
162	Al Huzafa contracting	\$ 12,619	\$ 21,348	1	2	450	25	✓			✓					✓		
163	Al Huzafa contracting	\$ 1,522	\$ 1,739	4	8	1000	12							✓				
164	Rotaj Contracting	\$ 7,489	\$ 19,142	1	3	450	25	✓			✓					✓		
165	Rotaj Contracting	\$ 2,079	\$ 5,921	2	5	630	7			✓		✓					✓	
166	Al Malik Building Cont.	\$ 24,752	\$ 59,487	2	3	2000	45	✓			✓							
167	Al Blouki Building Cont.	\$ 5,758	\$ 22,774	1	3	630	25	✓			✓					✓		
168	Alice building contracting	\$ 8,526	\$ 20,007	1	2	450	20	✓			✓					✓		
169	Dubai Gate 1	\$ 3,525	\$ 1,875	3	26	900	12							✓				
170	Dubai Gate 1	\$ 4,240	\$ 10,760	2	45	1000	10			✓		✓						
171	Dubai Gate 1	\$ 1,130	\$ 1,043	2	2	1000	12							✓				✓
172	Marina Wharf 1	\$ 5,440	\$ 9,560	3	30	1000	10		✓				✓					
173	DEC Towers 1	\$ 5,520	\$ 16,480	4	23	1000	10		✓				✓					
174	DEC Towers 2	\$ 6,510	\$ 9,490	4	27	1000	10		✓				✓					
175	DEC podium	\$ 1,550	\$ 2,050	2	7	1000	12			✓				✓				✓
176	DEC Podium	\$ 2,100	\$ 2,300	1	5	1000	12			✓				✓				✓
177	DEC Podium	\$ 1,140	\$ 1,060	1	5	1000	12			✓				✓				✓
178	Cappadocia residence	\$ 2,755	\$ 2,145	2	5	1000	12			✓				✓				✓
179	Emerald residence	\$ 2,460	\$ 2,340	2	4	600	12			✓				✓				✓
180	Al Abdouli Group	\$ 17,976	\$ 63,546	2	11	800	50	✓			✓							
181	Al Mofrah Al Zahabi Cont.	\$ 16,140	\$ 71,860	2	10	1000	50	✓			✓							
182	Alice building contracting	\$ 5,940	\$ 19,060	1	3	450	25	✓			✓					✓		
183	City Creek Constriction	\$ 12,504	\$ 102,985	3	12	1000	70	✓			✓							
184	Medco Contracting	\$ 3,550	\$ 14,113	1	2	450	20	✓			✓					✓		
185	AIMS Contracting	\$ 19,522	\$ 37,543	2	2	450	40	✓			✓					✓		
186	Najmat Al Fawares Cont.	\$ 21,809	\$ 99,115	5	2	630	90	✓			✓							
187	Khansaheb Constriction	\$ 67,338	\$ 135,663	7	2	630	120	✓			✓					✓		
188	Sik Construct	\$ 28,256	\$ 60,059	1	9	5000	45	✓			✓							
189	Sik Construct	\$ 10,654	\$ 31,466	1	8	1000	30	✓			✓							
190	Sik Construct	\$ 28,308	\$ 58,649	1	8	5000	40	✓			✓							
191	Sik Construct	\$ 9,463	\$ 25,319	1	3	1000	25	✓			✓							
192	Sik Construct	\$ 22,030	\$ 49,166	2	4	1000	30	✓			✓							
193	Moon Link Contracting	\$ 30,388	\$ 71,613	3	2	1150	60	✓			✓							
194	AIMS Contracting	\$ 5,170	\$ 19,830	1	2	450	20	✓			✓					✓		
195	AIMS Contracting	\$ 5,340	\$ 20,747	1	2	630	20	✓			✓					✓		
196	Ali Bin Ahmad Construction	\$ 1,623	\$ 21,475	1	3	800	25	✓			✓						✓	
197	Al Kaitoob contracting	\$ 9,265	\$ 35,235	1	25	450	60	✓			✓							
198	AIMS Contracting	\$ 6,945	\$ 19,142	1	2	630	20	✓			✓					✓		

APPENDIX (DATA 5)

No.		Name	Building type							Product type			Customer preference						Connection & link				Profitable project selection	
			Industrial		Commercial														Marke	Per. Jobs				
			Car lift	Parking lift	Construction lifts, Factory	High rise	Mid rise, offices, Hotel, School	Malls & public area	Hospitals & disability	Durbwater	Elevator	Escalator	Travellor	Less price	Innovation, new fixtures	Custom design	Luxury product	Speed of service	Leak of resource	Safety & quality	Site visit of sales	Advertising		Previous customer
1	Cubics design							✓	✓										✓					✓
2	Al Jawal Contracting								✓					✓					✓					✓
3	Saeed Mohammad Proj.								✓									✓	✓				✓	
4	Chicago construction					✓													✓				✓	
5	Al Suwaidi contracting								✓					✓					✓				✓	
6	Al Huzaila contracting								✓										✓				✓	
7	First art contracting								✓					✓		✓		✓	✓				✓	
8	Al Rams prime construction														✓		✓						✓	
9	Gover contracting								✓									✓					✓	
10	Gover contracting						✓			✓							✓				✓		✓	
11	QCD contracting								✓						✓				✓				✓	
12	QCD contracting											✓						✓			✓		✓	
13	QCD contracting														✓						✓		✓	
14	Al Madar engineering				✓																		✓	
15	Al Rossokh contracting								✓						✓			✓	✓				✓	
16	Chaminar											✓							✓				✓	
17	DCE contracting								✓										✓				✓	
18	DCE contracting						✓		✓										✓				✓	
19	DCE contracting						✓		✓										✓				✓	
20	DCE contracting					✓			✓										✓				✓	
21	DCE contracting					✓			✓										✓				✓	
22	DCE contracting				✓				✓										✓				✓	
23	DCE contracting						✓		✓										✓				✓	
24	DCE contracting						✓		✓										✓				✓	
25	DCE contracting						✓		✓										✓				✓	
26	AIA contracting								✓										✓				✓	
27	Al Kaitoob contracting				✓				✓										✓				✓	
28	Al Kaitoob contracting				✓				✓										✓				✓	
29	Al Kaitoob contracting				✓				✓										✓				✓	
30	Ideal system contracting				✓				✓			✓							✓				✓	
31	Intermass engineering						✓		✓			✓							✓			✓	✓	
32	Intermass engineering						✓		✓			✓							✓			✓	✓	
33	Intermass engineering						✓		✓			✓							✓			✓	✓	
34	Intermass engineering						✓		✓			✓							✓			✓	✓	
35	Intermass engineering						✓		✓			✓							✓			✓	✓	
36	Aljos building contracting								✓					✓					✓				✓	
37	Emirates European Hospital							✓	✓										✓			✓	✓	
38	Deira contracting							✓	✓					✓					✓				✓	
39	UBS contracting							✓	✓										✓				✓	
40	Al Memzar contracting				✓			✓	✓						✓		✓		✓			✓	✓	
41	Granada Europe Const.							✓	✓										✓				✓	
42	Granada Europe Const.							✓	✓										✓				✓	
43	Granada Europe Const.							✓	✓										✓				✓	
44	Qasr Al Andalus cont.							✓	✓			✓							✓				✓	
45	Al Yaqin contracting							✓	✓						✓				✓		✓		✓	
46	Al Shafar National Cont.				✓			✓	✓								✓		✓			✓	✓	
47	SOBHA LLC							✓	✓										✓				✓	
48	SOBHA LLC							✓	✓										✓				✓	
49	SOBHA LLC							✓	✓										✓				✓	
50	SOBHA LLC							✓	✓										✓				✓	

APPENDIX (DATA 6)

No.		Name	Building type							Product type			Customer preference						Connection & link		Profitable project selection		
			Industrial		Commercial														Marks	Per. Jobs			
			Car lift	Parking lift	Construction lifts, Factory	High rise	Mid rise, offices, Hotel, School	Malls & public area	Hospitals & disability	Dumbwaiter	Elevator	Escalator	Travellator	Less price	Innovation, new fixtures	Custom design	Luxury product	Speed of service	Leak of resource	Safety & quality		Site visit of sales	Advertising
51.	Alloe building contracting									✓				✓	✓							✓	✗
52.	Al Hamad contracting									✓													✗
53.	Al Zajil Building Cont.									✓													✗
54.	City Creek Constiction									✓							✓						✗
55.	City Creek Constiction									✓						✓	✓						✗
56.	Skyline contracting									✓								✓					✗
57.	Top Speed Contracting									✓					✓	✓							✓
58.	Top Speed Contracting									✓					✓	✓							✓
59.	Yas Contracting									✓			✓							✓			✗
60.	AGC Building Contracting									✓									✓				✓
61.	Span Steel Constiction				✓					✓					✓					✓			✓
62.	Al Warrag Building Cont.						✓			✓			✓								✓		✗
63.	Yas Contracting									✓					✓							✓	✓
64.	ASNC									✓					✓				✓				✓
65.	Constiction Consortium						✓			✓			✓							✓			✓
66.	Armada Contracting									✓					✓					✓			✗
67.	Armada Contracting									✓									✓				✓
68.	Intermass engineering									✓									✓				✗
69.	Intermass engineering									✓									✓				✗
70.	Intermass engineering									✓									✓				✗
71.	Intermass engineering									✓									✓				✗
72.	VICC						✓			✓									✓			✓	✗
73.	Sunshine Oasis Cont.									✓			✓		✓					✓			✓
74.	City Sky Contracting									✓					✓					✓			✗
75.	ASGC									✓									✓	✓			✗
76.	ASGC									✓									✓	✓			✗
77.	Granada Europe Const.									✓									✓	✓			✗
78.	Granada Europe Const.									✓									✓	✓			✗
79.	Dubai Sky Contracting									✓					✓					✓			✓
80.	Real House Contracting									✓							✓			✓			✗
81.	Ocean Star Constiction									✓						✓				✓			✓
82.	VICC						✓			✓									✓		✓		✗
83.	VICC									✓									✓			✓	✗
84.	Rotaj Contracting									✓					✓					✓			✓
85.	Rotaj Contracting									✓										✓			✓
86.	Advance contracting									✓					✓	✓				✓			✓
87.	Advance contracting									✓									✓		✓		✓
88.	Advance contracting									✓									✓		✓		✓
89.	ASCA Building Contracting									✓									✓	✓			✓
90.	Al Huzaila contracting									✓									✓		✓		✓
91.	Orascom Contracting									✓									✓	✓			✓
92.	Orascom Contracting									✓									✓	✓			✓
93.	Orascom Contracting									✓									✓	✓			✗
94.	Ashiyana Contracting									✓									✓	✓			✗
95.	Granada Europe Const.									✓									✓	✓			✗
96.	Granada Europe Const.									✓									✓	✓			✗
97.	Granada Europe Const.									✓									✓	✓			✓
98.	Bhatia General Cont.									✓									✓	✓			✓
99.	Bhatia General Cont.									✓									✓	✓			✗
100.	Bhatia General Cont.									✓									✓	✓			✓

APPENDIX (DATA 7)

No.		Name	Building type								Product type			Customer preference						Connection & link		Profitable project selection	
			Industrial		Commercial															Markets	Per. Jobs		
			Car lift	Parking lift	Construction lifts, Factory	High rise	Mid rise, offices, Hotel, School	Malls & public area	Hospitals & disability	Dumbwaiter	Elevator	Escalator	Travellator	Less price	Innovation, new fixtures	Custom design	Luxury product	Speed of service	Leak of resource	Safety & quality	Site visit of sales		Advertising
101	Armada Contracting					✓				✓								✓					✗
102	City Space Contracting									✓					✓				✓				✓
103	ASGC									✓													✓
104	Khoory Hill Building & Cont.	✓								✓					✓				✓				✗
105	Emirates Sands Contracting									✓					✓				✓				✗
106	Emirates Sands Contracting									✓					✓	✓			✓				✗
107	Emirates Sands Contracting									✓			✓								✓		✗
108	Excel Engendering & Cont.									✓					✓								✓
109	Pantheon Group									✓									✓				✓
110	Pantheon Group									✓									✓				✗
111	Al Ishrak Contracting					✓				✓									✓				✗
112	Al Ishrak Contracting					✓				✓									✓				✗
113	Projeco Contracting									✓					✓				✓				✓
114	Moon Link Contracting									✓									✓				✗
115	Dream House Contracting					✓				✓									✓				✗
116	Khansaheb Constriction				✓					✓				✓				✓	✓			✓	✗
117	Khansaheb Constriction				✓					✓				✓				✓	✓			✓	✗
118	Khansaheb Constriction				✓					✓				✓				✓	✓			✓	✗
119	Khansaheb Constriction									✓				✓					✓		✓		✗
120	Khansaheb Constriction									✓				✓					✓		✓		✗
121	Al Sakher Contracting									✓				✓		✓			✓				✓
122	Al Sakher Contracting									✓				✓					✓				✗
123	Al Sakher Contracting									✓				✓					✓				✗
124	Sarah Bulding Contracting									✓				✓		✓			✓				✗
125	Sarah Bulding Contracting									✓				✓					✓				✗
126	Sarah Bulding Contracting									✓				✓					✓				✗
127	Al Ishrak Contracting					✓				✓				✓					✓				✗
128	Al Ishrak Contracting						✓			✓							✓		✓				✗
129	OMIS Contracting				✓					✓									✓				✗
130	OMIS Contracting				✓					✓									✓				✗
131	OMIS Contracting		✓							✓					✓				✓				✗
132	City Sky Contracting									✓				✓					✓				✗
133	City Sky Contracting									✓								✓	✓				✓
134	City Sky Contracting									✓				✓					✓				✓
135	Loyal Group			✓						✓					✓				✓				✓
136	Al Manakh Building Cont.					✓				✓				✓					✓				✗
137	Al Manakh Building Cont.									✓									✓				✓
138	Al Sakher Contracting									✓				✓					✓				✗
139	Al Sakher Contracting									✓				✓					✓				✗
140	Al Sakher Contracting									✓				✓					✓				✗
141	Al Sakher Contracting					✓				✓							✓		✓				✓
142	VGC Bulding Contracting									✓									✓				✗
143	Orascom Contracting					✓				✓					✓				✓				✗
144	Orascom Contracting									✓									✓				✗
145	Orascom Contracting						✓			✓									✓				✗
146	Orascom Contracting			✓						✓									✓				✗
147	Alice building contracting									✓									✓				✗
148	Alice building contracting									✓									✓				✗
149	Granada Europe Const.					✓				✓									✓				✗
150	Granada Europe Const.					✓				✓									✓				✗

APPENDIX (DATA 8)

No.		Name	Building type							Product type			Customer preference						Connection & link		Profitable project selection		
			Industrial		Commercial														Marks	Per. Jobs			
			Car lift	Parking lift	Construction lifts, Factory	High rise	Mid rise, offices, Hotel, School	Malls & public area	Hospitals & disability	Dumbwater	Elevator	Escalator	Travellator	Less price	Innovation, new fixtures	Custom design	Luxury product	Speed of service	Leak of resource	Safety & quality		Site visit of sales	Advertising
151	Granada Europe Const.					✓					✓							✓			✓		✗
152	Sterling House Building Cont.										✓							✓			✓		✗
153	Alice building contracting										✓							✓			✓		✗
154	Bhatia General Cont.										✓										✓		✗
155	Bhatia General Cont.										✓							✓			✓		✗
156	Emkaan Engineering Consult.										✓				✓				✓		✓		✗
157	ASGC										✓							✓			✓		✗
158	Bhatia General Cont.			✓																	✓		✓
159	Bhatia General Cont.			✓											✓						✓		✓
160	Transfast Building Cont.										✓								✓				✗
161	Ocean Star Constidion										✓				✓						✓		✓
162	Al Huzaiifa contracting										✓										✓		✓
163	Al Huzaiifa contracting										✓										✓		✓
164	Rotaj Contracting										✓										✓		✓
165	Rotaj Contracting										✓										✓		✓
166	Al Malik Building Cont.										✓				✓				✓				✗
167	Al Blouki Building Cont.										✓								✓				✗
168	Alice building contracting										✓				✓						✓		✗
169	Dubai Gate 1				✓						✓							✓			✓		✗
170	Dubai Gate 1				✓						✓							✓			✓		✗
171	Dubai Gate 1										✓							✓			✓		✓
172	Marina Wharf 1				✓						✓							✓			✓		✓
173	DEC Towers 1				✓						✓							✓			✓		✗
174	DEC Towers 2				✓						✓							✓			✓		✗
175	DEC podium												✓					✓			✓		✓
176	DEC Podium												✓	✓							✓		✓
177	DEC Podium										✓		✓	✓							✓		✓
178	Cappadodia residence										✓		✓	✓							✓		✓
179	Emerald residence												✓								✓		✓
180	Al Abdouli Group					✓					✓							✓	✓		✓		✗
181	Al Mofteh Al Zahabi Cont.					✓												✓	✓		✓		✗
182	Alice building contracting											✓									✓		✗
183	City Creek Constidion					✓					✓							✓			✓		✗
184	Medco Contracting										✓								✓				✗
185	AIMS Contracting										✓								✓				✗
186	Najmat Al Fawares Cont.										✓				✓				✓		✓		✗
187	Khansaheb Constidion										✓								✓				✗
188	Six Construct						✓				✓							✓			✓		✗
189	Six Construct						✓				✓							✓					✗
190	Six Construct						✓				✓							✓					✗
191	Six Construct						✓				✓							✓					✗
192	Six Construct						✓				✓							✓					✗
193	Moon Link Contracting						✓				✓							✓			✓		✗
194	AIMS Contracting											✓									✓		✗
195	AIMS Contracting										✓				✓						✓		✗
196	Ali Bin Ahmad Construction										✓							✓					✗
197	Al Kaitoob contracting				✓										✓						✓		✗
198	AIMS Contracting										✓										✓		✗

APPENDIX (CIS TABLE)

Couple Index Matrix for Selected Projects CI_{ij}	Full package	Parts	Spare parts	Installation	Modernization	Repairing	Maintenance	Consultancy	Villa	Houses	Complex	Car lift	Parking lift	Construction lifts, Factory	High rise	Mid rise, offices, Hotel, School	Malls & public area	Hospitals & disability	Dumbwaiter	Elevator	Escalator	Travellator	Less price	Innovation, new fixtures	Custom design	Luxury product	Speed of service	Leak of resource	Safety & quality	Site visit of sales	advertising	Previous customer	Previous projects
Full package	1			0.685					0.651	0.320				0.525		0.551	0.619	0.258	0.551	0.878			0.435	0.071	0.674	0.559	0.275	0.351	0.634	0.851		0.320	0.479
Parts		1			0.375	0.750				0.361	0.188				0.375					0.526				0.188	0.146		0.208	0.333				0.565	
Spare parts			1		0.350		0.554				0.156	0.650								0.532				0.650				0.142			0.581		
Installation	0.653			1					0.540	0.201				0.356		0.379	0.612		0.473	0.764			0.391	0.074	0.419	0.248	0.189	0.265	0.596	0.727		0.330	0.166
Modernization		0.375	0.350		1					0.611										0.513									0.583			0.532	
Repairing		0.750				1			0.141	0.181	0.188				0.375					0.526				0.375	0.146		0.417	0.167				0.565	
Maintenance			0.554				1		0.216		0.707				0.288			0.288		0.583			0.331	0.505			0.122	0.160	0.120			0.655	0.110
Consultancy																																	
Villa	0.651			0.540		0.141	0.216		1										0.297	0.705			0.391	0.234	0.474	0.435	0.099	0.172	0.262	0.459		0.445	0.087
Houses	0.320	0.361	0.156	0.201	0.611	0.181				1										0.496			0.167	0.118	0.382	0.254	0.139	0.194		0.268		0.215	0.254
Complex		0.188	0.650			0.188	0.707				1									0.551			0.181	0.500	0.083		0.146	0.104	0.084			0.550	0.134
Car lift																																	
Parking lift																																	
Construction lifts, Factory	0.525			0.356										1						0.519					0.563					0.356		0.183	
High rise		0.375				0.375	0.288								1					0.513									0.583			0.532	
Mid rise, offices, Hotel, School	0.551			0.379												1				0.538			0.222		0.104				0.315	0.473		0.099	
Malls & public area	0.619			0.612													1			0.590			0.127				0.238	0.689	0.659			0.214	
Hospitals & disability	0.258						0.288											1		0.513			0.278	0.271		0.333	0.292		0.261		0.266		
Dumbwaiter	0.551			0.473					0.297										1	0.538			0.111		0.104			0.625	0.105	0.189		0.398	0.155
Elevator	0.878	0.526	0.532	0.764	0.513	0.526	0.583		0.705	0.496	0.551			0.519	0.513	0.538	0.590	0.513	0.538	1			0.581	0.551	0.654	0.545	0.538	0.577	0.647	0.764		0.699	0.545
Escalator																																	
Travellator																																	
Less price	0.435			0.391			0.331		0.391	0.167	0.181					0.222	0.127	0.278	0.111	0.581			1		0.146		0.333		0.099	0.313		0.351	0.397
Innovation, new fixtures	0.071	0.188	0.650	0.074		0.375	0.505		0.234	0.118	0.500									0.551				1			0.146		0.084			0.629	
Custom design	0.674	0.146		0.419		0.146			0.474	0.382	0.083			0.563		0.104		0.271	0.104	0.654			0.146		1	0.369	0.208	0.188		0.515	0.185	0.277	
Luxury product	0.559			0.248					0.435	0.254										0.545						0.369	1			0.248		0.175	0.286
Speed of service	0.275	0.208		0.189		0.417	0.122		0.099	0.139	0.146						0.238	0.333	0.538			0.333	0.146	0.208		1			0.284		0.298	0.310	
Leak of resource	0.351	0.333	0.142	0.265	0.583	0.167	0.160		0.172	0.194	0.104				0.583			0.292	0.625	0.577								1		0.212		0.462	0.113
Safety & quality	0.634			0.596			0.120		0.262		0.084					0.315	0.689		0.105	0.647			0.099	0.084					1	0.629		0.114	0.093
Site visit of sales	0.851			0.722					0.459	0.268				0.356	0.473	0.659	0.261	0.189	0.764			0.313		0.515	0.248	0.284	0.212	0.629	1			0.248	
advertising																																	
Previous customer	0.320	0.565	0.581	0.330	0.532	0.565	0.605		0.445	0.215	0.550			0.183	0.532	0.099		0.266	0.398	0.699			0.351	0.629	0.185	0.175	0.298	0.462	0.114		1		
Previous projects	0.479			0.166			0.110		0.087	0.254	0.134					0.214		0.155	0.545			0.397		0.277	0.286	0.310	0.113	0.093	0.248			1	

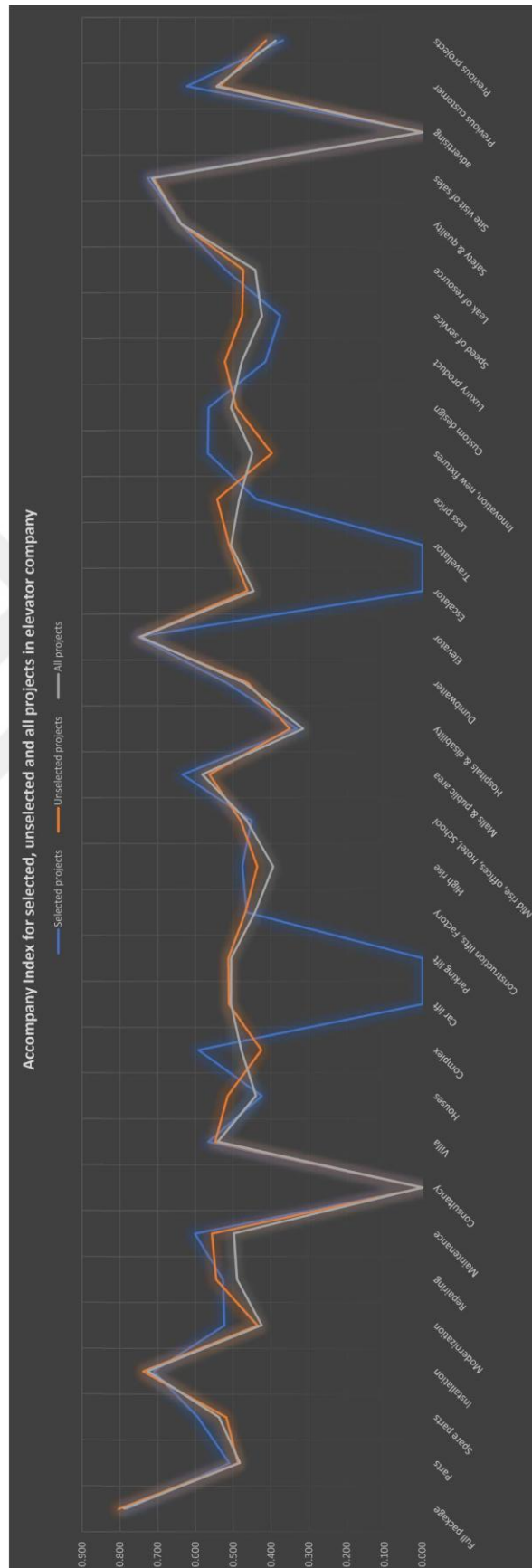
APPENDIX (CIU TABLE)

Couple Index Matrix for Unselected Projects $CI_{ij}U$																																	
	Full package	Parts	Spare parts	Installation	Modernization	Repairing	Maintenance	Consultancy	Villa	Houses	Complex	Car lift	Parking lift	Construction lifts, Factory	High rise	Mid rise, offices, Hotel, School	Malls & public area	Hospitals & disability	Dumbwaiter	Elevator	Escalator	Travellator	Less price	Innovation, new fixtures	Custom design	Luxury product	Speed of service	Leak of resource	Safety & quality	Site visit of sales	advertising	Previous customer	Previous projects
Full package	1			0.632					0.632	0.525	0.421	0.505	0.505	0.509	0.430	0.594	0.605	0.342	0.514	0.913	0.523	0.505	0.611	0.352	0.564	0.559	0.539	0.475	0.718	0.840	0.613	0.523	
Parts		1		0.250	0.475										0.327	0.144		0.292	0.519								0.298	0.309			0.406	0.161	
Spare parts			1	0.750	0.825					0.151	0.361				0.163				0.519				0.140	0.417							0.542		
Installation	0.913			1					0.540	0.537	0.304	0.505	0.505	0.511	0.437	0.465	0.540	0.344	0.344	0.835	0.526	0.505	0.612	0.354	0.451	0.481	0.523	0.381	0.643	0.752		0.564	0.451
Modernization		0.250	0.750		1					0.151	0.181				0.163			0.292	0.519			0.140	0.208				0.149	0.154			0.406	0.161	
Repairing		0.875				1									0.410	0.186			0.514								0.190	0.392			0.531		
Maintenance			0.625				1			0.556									0.505				0.583								0.510		
Consultancy																																	
Villa	0.632			0.540					1											0.592			0.324	0.101	0.424	0.557	0.082	0.140	0.138	0.383	0.415	0.106	
Houses	0.525		0.151	0.537	0.151					1					0.130	0.228			0.527			0.456	0.062	0.065	0.351	0.110	0.528		0.110	0.528	0.073	0.186	
Complex	0.421		0.361	0.304	0.181	0.556					1				0.150				0.542			0.212	0.278			0.159	0.264	0.249	0.330				
Car lift	0.505			0.505								1							0.505						0.536			0.529			0.507		
Parking lift	0.505			0.505									1						0.505						0.536						0.510		
Construction lifts, Factory	0.509			0.511										1					0.509						0.286		0.274	0.260			0.521		
High rise	0.430	0.327	0.163	0.437	0.163	0.410				0.130					1				0.474					0.365	0.074		0.249	0.475	0.440	0.361	0.293	0.223	
Mid rise, offices, Hotel, School	0.594	0.144		0.465	0.186					0.228	0.150					1			0.598	0.119		0.275					0.172	0.146	0.356	0.388	0.326	0.110	
Malls & public area	0.605			0.540													1		0.475	0.487	0.522	0.111				0.120	0.228		0.579	0.568	0.161	0.287	
Hospitals & disability	0.342	0.292		0.344	0.292													1	0.333	0.514			0.182	0.202		0.190	0.196		0.347		0.202		
Dumbwaiter	0.514			0.344															0.333	1	0.514		0.182						0.588	0.347	0.177		
Elevator	0.913	0.519	0.519	0.913	0.519	0.514	0.505		0.592	0.527	0.542	0.505	0.505	0.509	0.474	0.598	0.475	0.514	0.514	1			0.615	0.264	0.525	0.561	0.541	0.511	0.619	0.771	0.619	0.444	
Escalator	0.523			0.526												0.119	0.487				1						0.248		0.331	0.213	0.442		
Travellator	0.505			0.505													0.522					1								0.510	0.507	0.510	
Less price	0.611		0.140	0.612	0.140				0.324	0.456	0.212				0.275	0.111	0.182	0.182	0.615				1			0.107	0.195	0.045		0.415	0.358	0.254	
Innovation, new fixtures	0.352	0.417	0.354	0.208		0.583			0.101	0.278					0.365				0.264					1				0.338	0.375	0.270	0.281	0.357	
Custom design	0.564			0.451					0.424	0.062	0.536	0.536	0.286	0.074			0.202		0.525						1	0.148		0.261	0.381	0.231	0.071		
Luxury product	0.559			0.481					0.557	0.065							0.120		0.561				0.107	0.148	1		0.068	0.196	0.451	0.244	0.223		
Speed of service	0.539	0.298		0.523	0.149	0.190			0.082	0.351	0.159			0.274	0.249	0.172	0.228	0.190	0.541	0.248		0.195				1	0.053	0.240	0.427	0.171	0.357		
Leak of resource	0.475	0.309	0.154	0.383	0.154	0.392			0.140		0.529				0.475	0.146	0.196	0.588	0.511			0.045	0.338	0.261	0.068	0.053	1	0.159	0.397	0.239	0.195		
Safety & quality	0.718			0.843					0.138	0.110	0.264			0.260	0.440	0.356	0.579		0.619	0.331	0.510		0.375			0.196	0.240	0.159	1	0.632	0.313	0.277	
Site visit of sales	0.840			0.752					0.383	0.528	0.249	0.507			0.361	0.388	0.568	0.347	0.347	0.771	0.213	0.507	0.415	0.270	0.381	0.451	0.427	0.397	0.632	1	0.103	0.509	
advertising																																	
Previous customer	0.613	0.406	0.542	0.564	0.406	0.531	0.510		0.415	0.073	0.330		0.510	0.521	0.293	0.326	0.161		0.177	0.619	0.442	0.510	0.358	0.281	0.231	0.244	0.171	0.239	0.313	0.103	1		
Previous projects	0.523	0.161		0.451	0.161				0.106	0.186					0.223	0.110	0.287	0.202	0.444				0.254	0.357	0.071	0.223	0.357	0.195	0.277	0.509		1	

APPENDIX (CIA TABLE)

Couple Index Matrix for All Projects $CI_{ij}A$																																		
	Full package	Parts	Spare parts	Installation	Modernization	Repairing	Maintenance	Consultancy	Villa	Houses	Complex	Car lift	Parking lift	Construction lifts, Factory	High rise	Mid rise, offices, Hotel, School	Malls & public area	Hospitals & disability	Dumbwaiter	Elevator	Escalator	Travellator	Less price	Innovation, new fixtures	Custom design	Luxury product	Speed of service	Leak of resource	Safety & quality	Site visit of sales	advertising	Previous customer	Previous projects	
Full package	1			0.698					0.625	0.458	0.227	0.503	0.503	0.515	0.363	0.576	0.609	0.309	0.527	0.894	0.515	0.503	0.549	0.193	0.596	0.559	0.472	0.424	0.690	0.816		0.502	0.509	
Parts		1		0.292	0.894				0.161	0.092					0.288	0.078		0.163		0.522				0.098	0.076		0.243	0.319				0.482	0.086	
Spare parts			1	0.556	0.456				0.147	0.510					0.089					0.524			0.065	0.548					0.146			0.557		
Installation	0.698			1					0.519	0.429	0.165	0.504	0.504	0.414	0.369	0.442	0.565	0.207	0.414	0.800	0.518	0.504	0.536	0.197	0.402	0.400	0.442	0.333	0.628	0.743		0.476	0.356	
Modernization		0.292	0.556		1				0.304	0.113					0.117			0.183		0.516			0.093	0.119			0.102	0.302				0.448	0.107	
Repairing		0.894				1			0.080	0.089	0.101				0.314	0.087				0.519				0.214	0.085		0.270	0.266				0.544		
Maintenance			0.456				1		0.176	0.521					0.069			0.136		0.538			0.228	0.429			0.054	0.106	0.086		0.547	0.060		
Consultancy																																		
Villa	0.625			0.519	0.080	0.176			1										0.191	0.643			0.342	0.176	0.448	0.498	0.080	0.153	0.183	0.409	0.421	0.096		
Houses	0.458	0.161	0.147	0.429	0.304	0.089				1					0.102	0.167				0.514			0.360	0.054	0.186	0.129	0.291	0.070	0.075	0.441	0.121	0.208		
Complex	0.227	0.092	0.510	0.165	0.113	0.101	0.521				1				0.090					0.546			0.196	0.391	0.043		0.144	0.047	0.182	0.134	0.429	0.053		
Car lift	0.503			0.504								1								0.503				0.513										
Parking lift	0.503			0.504									1							0.503				0.513									0.506	
Construction lifts, Factory	0.515			0.414										1						0.514				0.453		0.119		0.107	0.208			0.319		
High rise	0.363	0.288	0.089	0.369	0.117	0.314	0.069			0.102					1					0.468				0.207	0.046		0.207	0.455	0.363	0.300	0.317	0.171		
Mid rise, offices, Hotel, School	0.576	0.078		0.442	0.087				0.167	0.090						1				0.568	0.116		0.254	0.029		0.137	0.099	0.340	0.397	0.263	0.079			
Malls & public area	0.609			0.565													1			0.519	0.454	0.514	0.117			0.077	0.224		0.617	0.602	0.099	0.261		
Hospitals & disability	0.309	0.163		0.207	0.183		0.136											1	0.156	0.514			0.220	0.226		0.237	0.234		0.313	0.106	0.124			
Dumbwaiter	0.527			0.414					0.191										0.156	1	0.524		0.131	0.069				0.582	0.063	0.239	0.309	0.079		
Elevator	0.894	0.522	0.524	0.899	0.516	0.519	0.538		0.643	0.514	0.546	0.503	0.503	0.514	0.468	0.568	0.519	0.514	0.524	1			0.600	0.423	0.587	0.554	0.531	0.538	0.624	0.766	0.650	0.477		
Escalator	0.515			0.518											0.116	0.454					1						0.237		0.321	0.208	0.425			
Travellator	0.503			0.504													0.514					1							0.507	0.504	0.506			
Less price	0.549		0.065	0.536	0.093		0.228		0.342	0.360	0.196				0.254	0.117	0.220	0.131	0.600			1		0.069	0.070	0.227	0.027	0.034	0.378	0.355	0.303			
Innovation, new fixtures	0.193	0.098	0.548	0.197	0.119	0.214	0.429		0.176	0.054	0.391				0.207					0.423				1			0.054	0.159	0.214	0.120	0.462	0.179		
Custom design	0.596	0.076		0.402	0.085				0.448	0.186	0.043	0.513	0.513	0.453	0.046	0.029		0.226	0.069	0.587			0.069		1	0.229	0.063	0.213	0.434	0.195	0.148			
Luxury product	0.559			0.400					0.498	0.129							0.077			0.554			0.070		0.229	1		0.042	0.128	0.380	0.219	0.244		
Speed of service	0.472	0.243		0.442	0.102	0.270	0.054		0.080	0.291	0.144			0.119	0.207	0.137	0.224	0.237		0.531	0.237		0.227	0.054	0.063		1	0.036	0.179	0.386	0.199	0.339		
Leak of resource	0.424	0.319	0.146	0.333	0.302	0.266	0.106		0.153	0.070	0.047	0.517			0.455	0.099	0.234	0.582	0.538			0.027	0.159	0.213	0.042	0.036	1	0.097	0.322	0.330	0.164			
Safety & quality	0.690		0.628			0.086			0.183	0.075	0.182			0.107	0.363	0.340	0.617		0.063	0.624	0.321	0.507	0.034	0.214		0.128	0.179	0.097	1	0.630	0.241	0.216		
Site visit of sales	0.816			0.743					0.409	0.441	0.134	0.504		0.208	0.300	0.397	0.602	0.313	0.239	0.766	0.208	0.504	0.378	0.120	0.434	0.380	0.386	0.322	0.630	1	0.063	0.420		
advertising																																		
Previous customer	0.502	0.482	0.537	0.476	0.448	0.544	0.547		0.421	0.121	0.429		0.506	0.319	0.317	0.263	0.099	0.106	0.309	0.630	0.425	0.506	0.355	0.462	0.195	0.219	0.199	0.330	0.241	0.063		1		
Previous projects	0.509	0.086		0.356	0.107		0.060		0.096	0.208	0.053				0.171	0.079	0.261	0.124	0.079	0.477			0.303	0.179	0.148	0.244	0.339	0.164	0.216	0.420			1	

APPENDIX (DIAGRAM)



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