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REVIEW

Cost Estimation for Modernization of Metro Terminal Stations Using ANN Technique

Ahmed Abdelmoamen Khali[1]* and M. Abdel Rahman[2]

1. Faculty of Engineering, Shoubra Benha University, Shoubra, 11629, Egypt
2. Railway Track Engineer, Cairo Metro Company, Cairo, Egypt

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ABSTRACT

The current situation of Cairo metro stations, especially terminal stations and its surrounding areas, has bad financial revenue and bad effect on environment. It is a major factor in increasing of noise, traffic jam and air pollution, in addition to, spreading of street vendors, collecting of random parking around these terminal stations. Thus, this paper proposed a methodology helping to apply multilateral investments in metro terminal stations for getting extra profits and decreasing the bad environmental effect of terminal stations and its surrounding areas. Hence, Helwan-Metro station on line 1 has been considered as a case study. Number of passengers at peak time, their ages, and their destinations, have been considered by making a field survey and a questionnaire. After collecting data and finalizing the surveying questionnaire, primary studies were done to modify and introduce a new proposal for Helwan-Metro station. The initial cost of the proposed project is predicted by using Artificial Neural Network technique using Just NN software. The investment feasibility achieved by consideration of Life Cycle Cost analysis and calculation of Net Present Value (NPV) of the proposed project.

1. Introduction

Metro stations attract large numbers of passengers daily who make different impacts on surrounding areas. These impacts usually appear around stations, sometimes around transit corridors and in some cases as a combination of both [1]. Therefore, during the recent decades, development of metro stations in urban regions has significantly affected spatial flows and urban mobility as well as spatial development of urban areas. Improving availability of employment nucleuses, retail districts and essential facilities for citizens is the most obvious impact of this development. Such positive impacts can raise land values around metro stations and consequently it can provide especial opportunities for urban textures to improve their quality [2, 3].

Nowadays, there is an increase in population and unemployment in Cairo, which leads to increase the private modes of transportation, for example, microbuses. These facilities move randomly in several places around metro stations and their surrounding streets that leading to traffic jams, also, closing many streets which founded from

**Corresponding Author:*
Ahmed Abdelmoamen Khalil
Faculty of Engineering, Shoubra Benha University, Shoubra, 11629*, Egypt*
Email: ahmed.khalil@feng.bu.edu.eg

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several decades. Also unemployment led to presence of a lot of vendors inside metro cars and around metro stations. Because of their large numbers, almost areas around station have been closed as shown in Fig. 1. The result is bad environmental effect like noise pollution that reach to 85 dB at rush hours and air pollution emissions such CO, CO2, NO, NO_2, SO and SO_2 [4, 5]. This problem must be resolved with technical solution.

Figure 1. Current situation around Helwan terminal station

In practice, constrained capacity at many older stations creates a conflict between enhancing the retail offer and improving passenger flows, but station investment can address this in a number of ways [6]. At some stations, it may be possible to create additional space, for example by creating a separate concourse level, or reconfigure the layout so that there is a clear separation between retail and other areas. More generally, the provision of clear signing and consistent way finding within and beyond the station boundary, as well as the removal of clutter, can improve passenger flows and make passengers feel more relaxed [7].

It was focused on a number of possible applications of some solutions world-wide and on specific factors that allowed for their implementation. It concludes that commercial activity development at railway stations meets a certain number of criteria, the first obviously being that of size and volume for passenger traffic. The operators interviewed, as part of this study, agree on a minimum volume of traffic 50,000 passengers/day as a prerequisite for developing a "bankable" commercial activity. This does not, of course, mean that commercial activities cannot be developed in smaller stations, but the critical size mentioned above is the threshold based on which part of the financing can be raised in terms of commercial revenues [8].

In recent years, a number of major stations have been reconfigured with a view to increasing the retail and other services available. At London Paddington, the main retail offer is located off the main concourse, removed from the main passenger flow while remaining visible and accessible to both passengers and the non-travelling public. Similarly, at Manchester Piccadilly a number of retail outlets have been placed on a separate level, while others have been separated from the passenger circulation and waiting areas, and there are current plans for further improvement and expansion of the retail facilities at the upper concourse level. In some cases, the retail offer at the station has been transformed such that the station location is now a destination in its own right. The clearest example of this is St Pancras, where approximately one quarter of station users have no intention of catching a train and visit the station entirely for the shopping, cafes and restaurants. The same phenomenon can also be observed at major stations across continental Europe [9]. There is strong evidence that the perception and economic performance of an area can be enhanced by the presence of well-designed buildings, and there is no reason why stations should be an exception[9].

The concentration of passengers with time to spare at a station creates an attractive market for many retailers. This has been recognized for many years by a number of established retail organizations, notably W H Smith, which opened its first station based outlets during the railway boom of the 1840s. Today, station based retail businesses are significantly outperforming high street shops; recent Network Rail data indicate that retail sales at stations increased by 5% in the last quarter of 2010 as compared with a 0.4% increase on the high street [10]. The design of today's stations tends to be different in expression from their early age. Presently, they are often designed in such a manner as to take advantage of existing structures that affect the spatial planning [11]. Attention is greatly paid to problem-solving of their interior spaces. There are four main functional areas typically housed in most stations; core, transition, peripheral, and administrative areas [12].

More functions are integrated, and numbers of passengers are increased. The stations appear to be more than people-processors, but can expedite people's lifestyles. Similar to the design of airport terminals, the trend of the station design is to take full advantage of the time passengers wait around by providing facilities and entertainment. It is evident that many grand stations in the United States, Great Britain, and Japan begin to look like shopping districts that become tourist attractions. Many urban functions are brought inside the stations. It gives the opportunity to bring together restaurants, retail outlets, cafes, offices, currency exchanges, banks, post offices, car rental companies, movie theaters, and so on. The historic Union Station in Washington, D.C. is a good example of this concept. The 600,000 square foot space has been adaptively redesigned and renovated to become a major

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retail, entertainment, and transportation center [2].

Helwan station is considered the case of study in this research as Helwan station and its surrounding area is one of the most stations that face this phenomenon because of spreading of slums, street vendors and random parking lots around the station. Thus, the bad effect on environment (noise, air pollution, visual pollution and traffic jam, etc.) has occurred. This research aims to use tools helping the authority of Cairo metro to make extra profit through investing in terminals, and to eliminate the phenomenon of street vendors inside and around metro stations. Thus, the authors propose a new project for transferring the old buildings to mega malls and car parking.

2. Material and Method

A field survey has been carried out by the authors, where, they counted the number of metro passengers, which arrive to Helwan-Metro station at peak times. Counting process has been done accurately in holidays and school time. Then, a sample of passengers has been selected to determine their ages and their genders. During holidays, the passengers have been asked about their destinations after exit from metro station to know number of parking lots that will be required and the number of required buses for each direction. Also, passengers have been asked about the number of days in which they use metro during week. After that, passengers have been asked about their opinions in the street vendor's phenomenon around the station and their opinions in the random markets. The questionnaire that has been used in the interviews is attached in Appendix A.

The initial cost of the proposed project is predicted by using Artificial Neural Network technique using Just NN software through six steps namely: 1) Determining output variables ; 2) Identifying input variables; 3) Data collection and encoding ; 4) ANN Structure design ; 5) Training & validation, and 6) Cost calculation [13, 14]. The software, firstly, determines the specific output variable to be used in predicting a preliminary estimation of construction cost at the feasibility study stage. Hence, it identifies the critical input variables which affect the construction cost [15]. The input data represents the attributes of the problem available at the early stage of the projects, which may affect the final cost of construction. Data have been collected from 13 metro and railway station projects. These projects have some common characteristics, which enable the predicting of preliminary estimation for similar new project [16, 17]. The collected data were randomly divided into 2 sets; training data set and a validation data set [18, 19]. The historical data that has been entered to the software to make both training and validation process, is shown in Table 1, and data of the proposed project in Helwan station is given in Table 2.

Table 1. Historical data within Just NN environment

No.	Project name	Area	No. of Floor	Park	Start Date	Const. duration	Marble Face	Mall	Output
P1	Cambridge station	17678	2	450	2016	2	True	False	52000000
P2	Williams landing	3700	3	500	2013	2	False	False	86000000
P3	Cairo station	17000	3	300	2013	3	False	False	34285000
P4	Sedy Gaber station	16250	3	850	2013	3	True	True	32143000
P5	Hadayek el Maady	3200	2	0	2014	4	True	True	6580000
P6	Mansheyt el Sadr	1800	2	0	2012	2	True	True	38500000
P7	New Delhi station	9000	3	800	2009	2	False	True	972000000
P8	Berlin station	70000	5	870	2006	11	False	True	1000000000
P9	Laverton station	11000	1	400	2011	3	True	False	96200000
P10	Hamburg St. station	27800	2	0	1991	6	False	True	6000000
P11	Northampton station	30500	3	1270	2015	1	False	True	40000000
P12	Franklin St. station	36910	2	750	2007	3	True	False	35000000
P13	Napoli train station	20000	5	1300	2012	9	False	True	70000000

Table 2. Data of the proposed project

No.	Project name	Area	No. of Floor	Park	Start Date	Const. duration	Marble Facade	Mall	Output
Q:13		3400	6	850	2016	2	True	True	Required

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3. Analysis

3.1 Analyzing the Field Survey Data

Analyzing the collected data and regarding the recorded answers in the questionnaire, it is found that passengers with ages between 24 and 60 years use metro mostly in holiday time and school time. The percentage of students with ages between 18 and 24 years doesn't exceed 7%.Whereas, during the school time this percentage reaches 15% of the total number of passengers. It is, also, found that most of passenger's destinations, after arriving Helwan station, are to other suburbs (Tebin – El Saff – Arab Ghonim – Ezbet el Walda – 15 may city – American project), in addition to original Helwan habitants. It is, also, found that distribution of passengers on those destinations are 15 may 29%, El Saff region 17%, El Tebin region 15%, American Project region 5% from the total number of passengers as shown in Fig. 2. The percentage of Helwan habitants is about 11%. The percentage of passengers distributed along the week days is shown in Fig. 3.

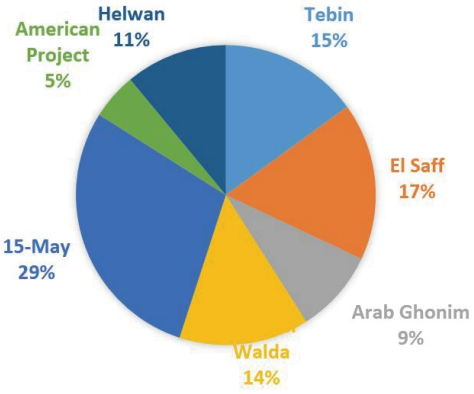

Figure 2. Passenger's destinations after passing Helwan station, from 14 pm to 17 pm

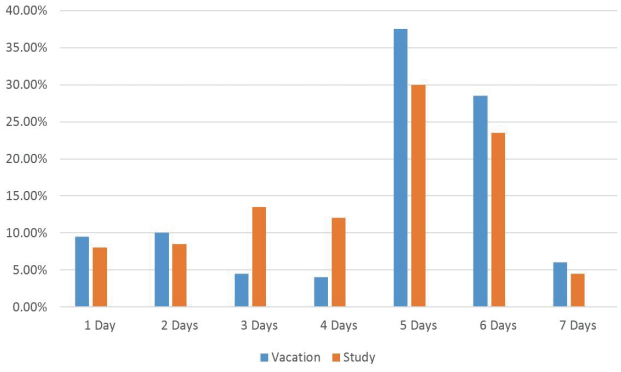

Figure 3. Numbers of passengers riding Metro from Helwan station during week

The interviewed passengers have been also asked about their opinions in the street vendor's phenomenon around station to determine their reaction with them. The answer was 25% almost of total number of passengers is impossible to buy from the street vendors even they are in a necessary need to buy. In contrary, the ratio of passengers who always buy from these random vendors which located around metro station was about 20%. Ratios of different answers of the passengers during school session and school vacancies are shown in Figs 4 and 5 respectively.

The remaining ratio of passengers (about 55%) sometimes has to buy from these street vendors when coming-out of the station as they are tired or in hurry, except for that they prefer buying from specialized places for the commodities they want. Most of the passengers recorded that street vendors' phenomenon around metro stations is indication of uncivilized phenomenon, as it, also, helps in increasing chaos and spread of bullying around the station, and it makes people feel unsafe. Introducing the idea of the proposed project to the asked passengers, it was found that most of them are deeply interested in the idea, and hope to finish this project as soon as possible. The proposed project will save their time and increase their safety in the streets, as well as, it will save their needs (stationery, food, clothes, transport means) in one building.

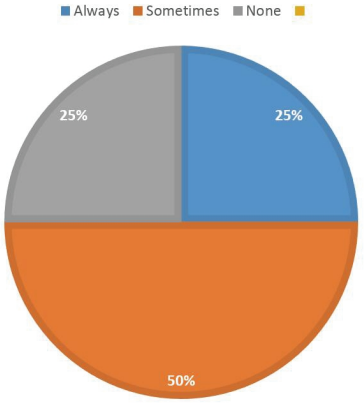

Figure 4. Shopping from Helwan Square during school session

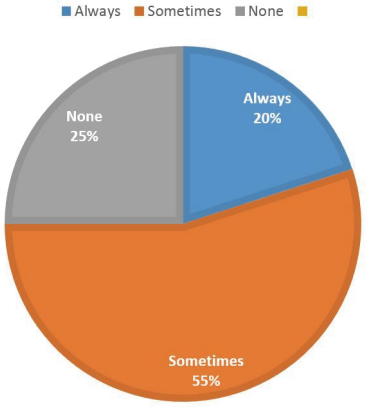

Figure 5. Shopping from Helwan Square during school vacancies

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3.2 Cost Estimation

After assigning the minimum accepted error (4%), ANN software starts to make the learning cycles of a training data set of 11 projects which from project 1 to 13 except projects 5&12 and a validation data set of 2 projects which are 5&12 to check the error. ANN chooses one hidden layer with five nodes to get the optimum result. Fig. 6 shows the weights for the network's inputs and Fig. 7 shows the graphical presentation of the network layers.

Fig. 8 illustrates the minimum, maximum and average error for learning within the learning cycles. In addition, this Figure shows the validating error for the system. Where: The horizontal axis is nonlinear to allow the whole learning progress to be displayed. As more cycles are executed the graph is squashed to the right. The red line is the maximum example error, the blue line is the minimum example error and the green line is the average example error. The orange line is the average validating error. When the Total Net Error value drops below the max error, the training is complete.

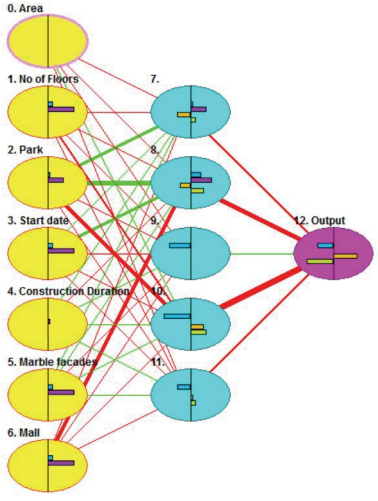

Figure 6. Relations between parameters

Column	Input Name	Importance	Relative Importance
2	Park	21.9772	
3	Start date	12.3957	
6	Mall	8.1684	
5	Marble facades	7.7736	
1	No of Floors	7.1807	
4	Construction Duration	3.6454	
0	Area	3.3485	

Figure 7. Importance of parameters

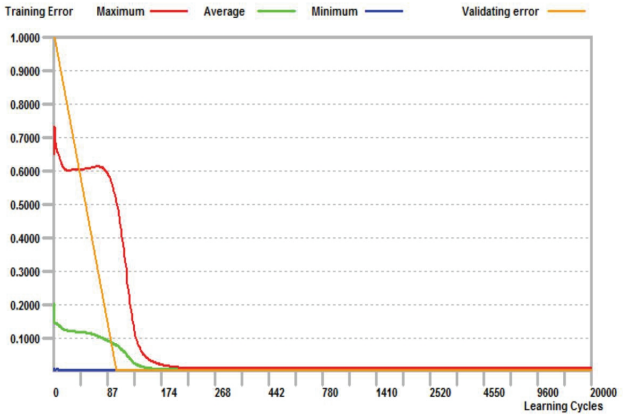

Figure 8. Error of the process

After running the program and getting the acceptable value of error, it is possible to calculate the construction cost of any new project. As a result, the initial construction cost of the proposed project is approximately $12,800,000 96,000,000L.E.

3.3 Net Present Value of the Proposed Project

Net Present Value has been calculated for the new building in Helwan-Metro station to get the total revenue of the project. Time value of money can be used to bring all future cash flows to their present-day equivalent value by Net Present Value. Therefore, the Length of study period is taken to be the operational lifetime of the station (i.e. 50 years) the interest rate (i) =18 %.

Equation 1 has been used to calculate the Net Present Value of the project:

$$NPV = -PV(I) - PV(A) - PV(N) + PV(M) + PV(T) \quad (1)$$

Where:

PV (I) is present value of initial costs;

PV (A) is present value of annual operation, maintenance, utility and other costs;

PV (N) is non-annual, operation, maintenance, utility and other costs.

PV (M) is present value of mall and parking cars, and

PV (T) is present value of tickets.

3.3.1 Annual Costs

The annual costs represent the costs required annually to cover operation, maintenance, utility works for the station. Equation 2 is used to calculate these costs. According to the Egyptian company of Cairo metro, the annual costs are 800,000 L.E. with annual up gradient 5 %.

$$PV(A) = A\left[\frac{1-\left(\frac{1+g1}{1+i}\right)^{n}}{i-g1}\right] \quad (2)$$

Therefore, present value of operation maintenance cost is calculated using equation 2:

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