

An efficient cost analysis of monorail in the Middle East using statistics of existing monorail and metro models

A. Ghafooripour¹, O. Ogwuda¹ & S. Rezaei²

¹*School of The Built Environment,*

Heriot-Watt University (Dubai Campus), UK

²*I. Azad University, Central Tehran Branch, Iran*

Abstract

This paper discusses an efficient-cost analysis for the monorail system in developing countries focusing on Middle East cases. Most of the cities in the Middle East are using the metro system and have experience with it. A monorail system is quite new for these countries so the efficiency of the monorail as an important question that is always understood. A function to find payback duration for the monorail is generated, using available data for countries which have both systems in the world. Then a correlation between metro and monorail ticket prices is studied to apply it for the countries in the Middle East. The theory has been verified for UAE, USA and China as existing models for both metro and monorail. Then it has been applied for interpreting and predicting monorail system costs in Egypt and Iran as case studies in the Middle East. The results show that for those countries with a subsidies policy for public transportation, a monorail will not be an economic system for public transportation; private sectors will not show their interest for long term investment in it and it might be used for tourism and amusement purposes.

Keywords: monorail, metro, efficient-cost, analysis, transportation, fare.

1 Introduction

A monorail system is one of rail transportation systems which are used to transport the passengers [1]. The monorail society defines the monorail as “A single rail serving as a track for passenger or freight vehicles. In most cases rail is elevated, but monorails can also run at grade, below grade or in subway



tunnels”. The first generally recognized monorail was the Schwebebahn (“swaying railroad”) in Wuppertal, Germany (1901) [2, 3]. Famous monorails have been constructed since 1957 (Figure 1). Despite the immense popularity monorails have had with the general public, this form of transportation has been mainly relegated to world’s fairs and amusement parks [3].

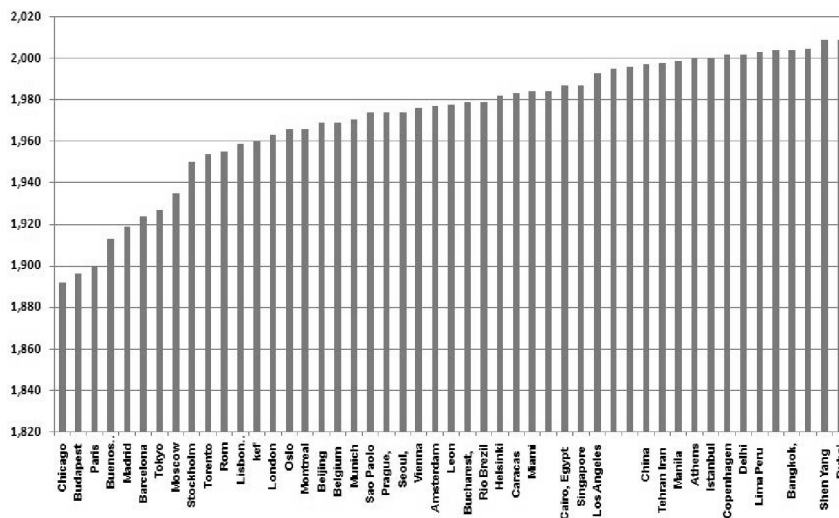


Figure 1: Inauguration year of famous monorails in the world.

This system has been used in short roads less than other rail systems (Figures 2 and 3) and new technology because of such advantages as lack of high traffic and of vocal pollution. Impossibility of using its infrastructure for other utility systems and less capacity for transporting the passenger in comparison with other rail ones is its disadvantages which should be noted to assess this system economically, however speed of construction and its possibility for the cities with complex underground infrastructures, organic or natural underground limitations such as water table level are its advantages.

Monorail system cost such as other transportation systems depends on different conditions summarized as follows (Figures 4 and 5):

Geography, Economic condition, Social interests, Technology availability, amount of investment, maintenance fees, Electrical Power/fuel local prices, Soil Condition and Geotechnical Considerations, Available infrastructure facilities, demand and population, People expectations, desired system for path and stations, number of desired station, total length of required network, size of wagons, immunity level of system, distance of path as compared with raw material and required machinery, Construction cost including the rate of labors, and engineer’s wage, environment condition, aesthetics expectation and confidence level of system which are different among cities and countries and also times. Accordingly, it is not easy to find cost of rendering or primary cost of system to make a decision on it especially in Middle East [1–4].

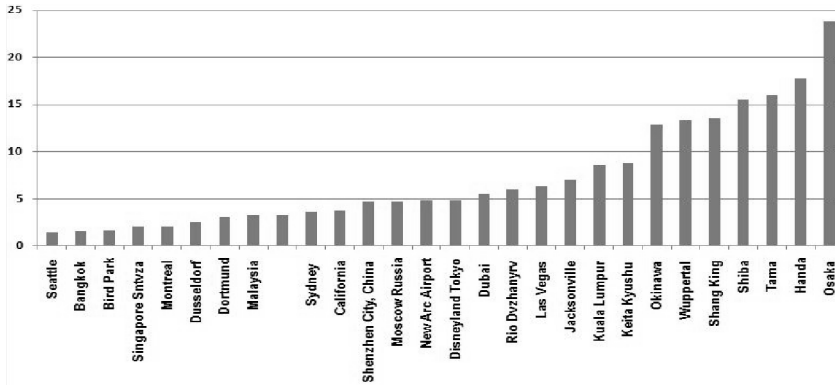


Figure 2: Length of monorails in different countries.

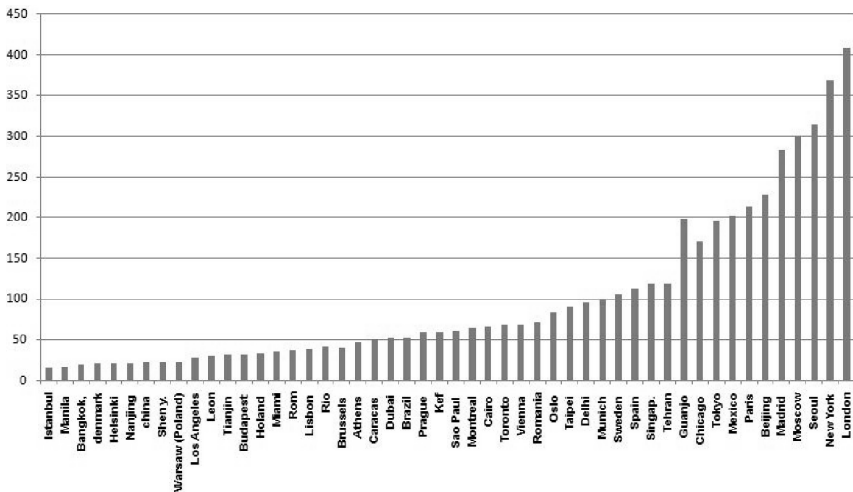


Figure 3: Length of metro railways in different countries.

Saudi Arabia, UAE, Egypt and Iran are countries which can be studied on them because of the number of population and/or economy condition. Saudi Arabia started monorail for the specific purpose but UAE as a country with sound economy and without subsidies for public transportation is selected as the bench mark in Middle East which both systems are available there. So, this paper focuses on three countries in middle-east as the case studies. Egypt, Iran and UAE (Dubai city) are samples for case studies. Fundamentally, Iran and Egypt have a good basis for monorail development and their population is almost the same. Available data for the Dubai monorail will be the base point for accuracy and interpretation of models.

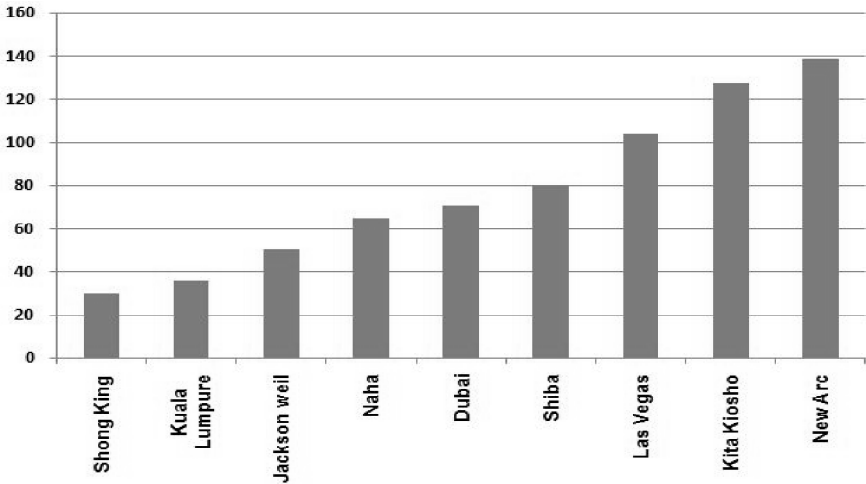


Figure 4: Construction cost of monorail-(Million\$/Km).

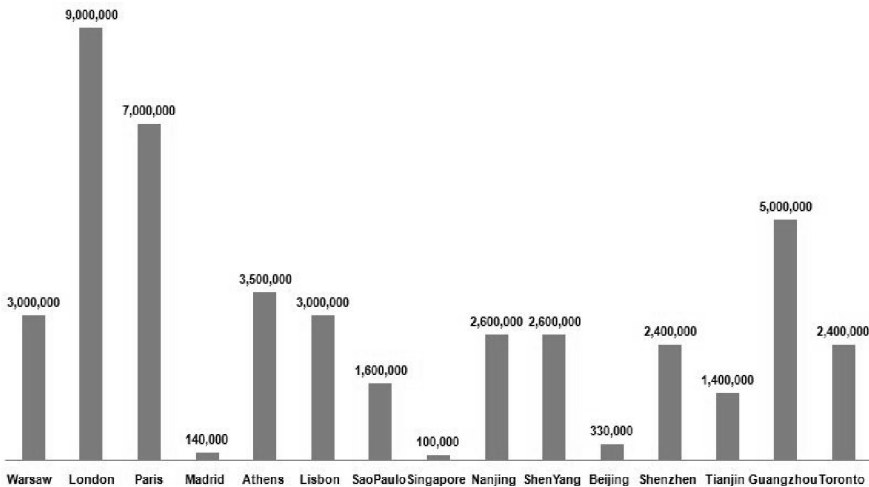


Figure 5: Construction cost of metro system-(Million\$/Km).

2 Successful and unsuccessful projects in Middle East

An example in the Middle East as a failed project of monorail is the Tehran monorail project. The project studies once in 1976 and rejected for the demand and efficient-cost and then again studied in 2003. Construction started in 2004 and due to the lack of resources and required studies completely stopped in 2008 and all 10 completed piers and 12 incomplete piers were demolished in 2010 (Figure 5) [5–8]. Comments on this project have been raised for the estimated construction cost of 12 million USD/km which is less than 1/3 of

minimum existing prices in the world and required maintenance fees due to the national-international costs for future maintenance and after sale services [6].

Example of another project close to failure is Qom city monorail in Iran. There are comments about the luxurious application of monorail in conjunction with the local people culture [9, 10] and although the construction was started on the May 2011, the feasibility of project for that city as the religious and holy points is now under question. The project is still under protests and pilgrims comments and has been stopped after several months (Figure 6) [10].

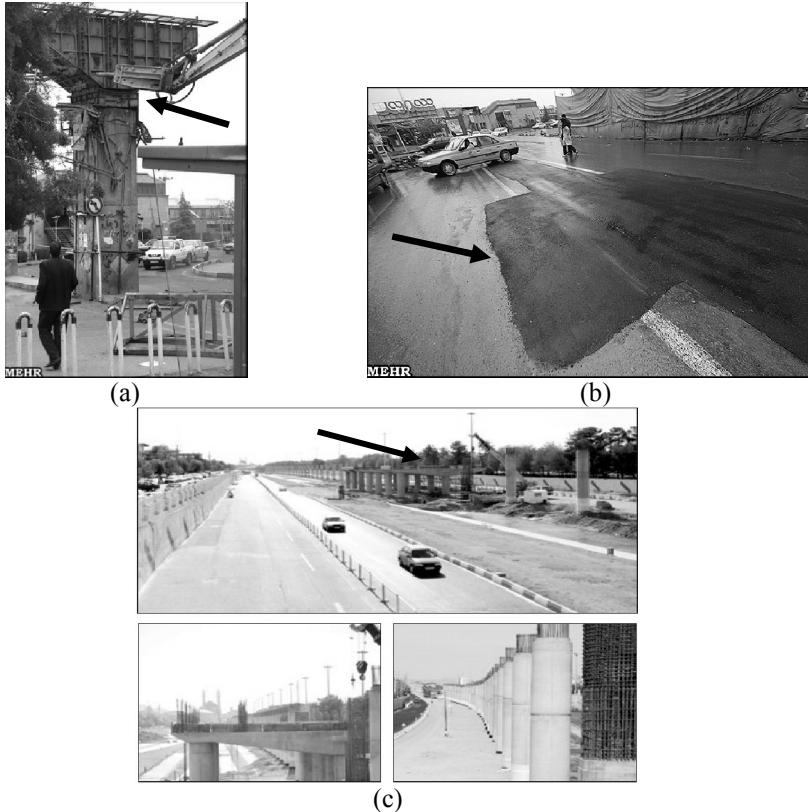


Figure 6: (a) Demolishing of monorail, (b) after demolishing of piers in Tehran, (c) monorail in Qom-Iran.

Despite to the Iranian negative comments on monorail application for pilgrims in Qom city, Saudi Arabia as the other country started the project of monorail for pilgrims on 2008. Saudi Arabia's monorail project is linking Makkah with the holy sites of Mina, Arafat and Muzdalifah. Studies are under way on extending the monorail to a station close to the Grand Mosque in Makkah. The SR6.5 billion new rail system will help transport at least 500,000 pilgrims within six to eight hours (Figure 7) [11–13].

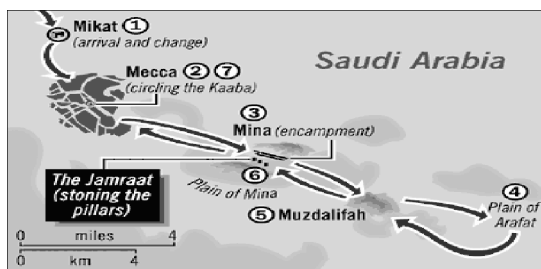


Figure 7: Saudi Arabia monorail plan.

The UAE-Dubai Palm Monorail is the first of its kind to be unveiled in the Middle East with the capacity to transport 2,400 passengers each hour. The 5.45 km monorail line began construction in March 2006 open April 2009 [14].

The Dubai monorail cost is 380 million USD and equivalent to 56 million round trip return ticket with 6.8 USD cost per round trip. The first experience in Arabian Peninsula has been designed for the purpose of tourism. Despite any judgment for the success of this project, the project is now described as a part of attractions in Dubai (Figure 8) [15, 16].



Figure 8: Monorail in Palm Jumeira – Dubai.

3 Problem description and investigation method

Although a few experiences exist in the Middle-East, each one has its specification based on the countries' expectations and the monorail application is sometimes under negotiation and comments. One of the methods to find a solution for a cost-benefit analysis of Monorail in these countries is to generate the cost and ticket price and find a correlation between metro and Monorail. This ratio for sound economies should be constant. Applying the ratio and compare it with the real construction site will show the possibilities in the case study. The estimated ticket price should not be less than the existing costs for construction and maintenance. Less price will have the meaning of subsidies or long term investment and prices proportion to the international samples and rates will show the feasibility of Monorail system for case studies.

Although, for each country, any other aspects and conditions might have effect on subject, but the main item will be the costs for construction and maintenance and this paper focused on it.

4 Statistics from different countries for monorail and metro

For the purpose of simulation the efficient-cost function for the Middle-East, statistical approach to collect data for this simulation shall be carried out for the following items have been considered:

- Construction cost in respect to the natural/environment condition
- Ticket price as the index for payback duration time and maintenance costs
- Total number of daily passengers
- Minimum possible of construction cost as per manufacturers proposed

A Sort of countries in different continentals selected. Construction cost has variation in different countries and even in the cities in one country such as Japan (Table 1).

Table 1: Construction cost and length of monorail network in different countries (M\$=million US Dollar).

No.	City	Country	Total length of network (km)	Usage for monorail	Cost (M\$)
					Per kilometer
1	Kuala Lumpur	Malaysia	8.6	Hotel shops, Central bank	36.2
2	New Arc	USA (New Jersey)	4.8	Airport	138.7
3	Jackson wail	USA (Florida)	7	Part of the city	50.4
4	Las Vegas	USA (Nevada)	6.3	Joy land	103.6
5	Kita Kiosho	Japan	8.8	Near city center	127.4
6	Shiba	Japan	15.5	Airport – In the city center	79.7
7	Naha	Japan (Okinawa)	12.8	Airport – In the city	64.6
8	Dubai	UAE	5.5	Tourist lands and Joy lands	70.9
Sum		8 countries	69.3	-	671.5
Average Sum		8 countries	8.7	-	83.9

It has been observed that the construction cost is also depends on the company which provide the monorail system and show scatter between companies’ suggestions and real cost of terminated projects. So, the real data for the terminated projects have been considered.

Comparison between Metro and monorail system costs shows that the average global construction cost of metro is less than monorail system however, in different cases Monorail are cheaper than Metro system. Almost all parts of Dubai metro are not underground. In this city the monorail cost is less than the metro cost. The ticket price for the monorail are generally more expensive than the metro ticket price for all cases (Table 2).

Table 2: Comparison of cost (metro with monorail).

Transportati on system	Description	European	American	Asian	Dubai
Monorail	Expenditure of building per km, (M\$)	N/A	95	68	70.5
	Ticket price (\$)-Average	5	5	5	4.15
Metro	Expenditure of building per km, (M\$)	230	90	58	102.2
	Ticket price (\$)-Average	4.5	4	1	1.3\$

A simple survey on monorail and metro capacities for the number of passengers shows that Most of the monorails are suitable for transporting 15,000 to 35,000 persons per hour and metro for transporting more than 35,000 persons (Figures 9 and 10) versus construction period is less than the time for underground works including tunnels and stations.

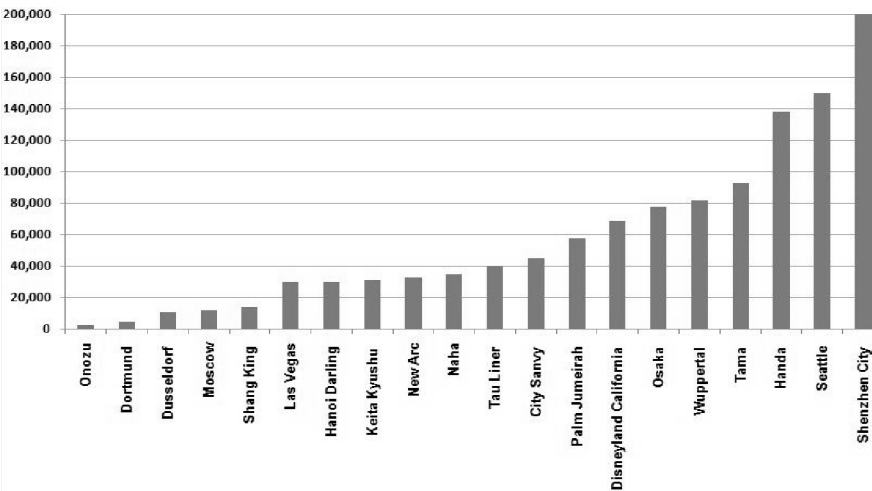


Figure 9: Daily capacity for monorail passengers.



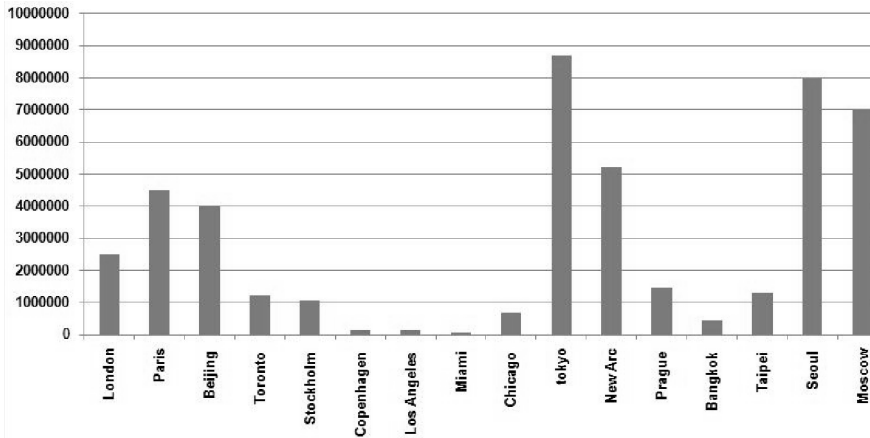


Figure 10: Daily capacity for metro passengers.

5 Analysis of statistics

To find a function for the monorail system, the following statistical approach has been derived:

N = number of daily passengers; L = length of monorail railway; C = monorail cost per Km. The investment payback time considered for 5 and 10 years separately. Then:

Ticket price = $C / \{(N/L) * 1825\}$ for 5 years payback and Ticket price = $C / \{(N/L) * 3650\}$ for 10 years payback.

The results of statistics show a good confidence in assumptions for selected countries and the calculated ticket prices with the assumptions are consistent to the real prices and the method for prediction of price will have enough confidence. To find the correlation between metro and monorail prices, a comparison between metro ticket price and monorail ticket price in the countries with sound economies, show a good consistency between them due to the big difference between the number of passengers for metro and monorail systems and the price for each are within a reasonable margin (Figure 11).

Statistics show a good correlation between the ratio of Monorail ticket price to Metro ticket price (RMM) for Dubai and the United States. However there is a big deviation for china. The ticket price for metro in china is significantly cheaper than the monorail (more than 12 times) (Figure 12). This will show an inconsistency for the developing countries. China subsidises the metro and this makes deviation from the real price. Applying the price of the metro in Cairo and Tehran for the extracted global RMM equal to 2, yields the monorail ticket price less than a dollar (prices discussed in Figure 13).

The monorail ticket price as an average in the world is around 5 dollars and due to subsidies the prices for metro in these 2 cases, at least 10 times deviations between minimum international RMM could be observed. So, Chinese model in

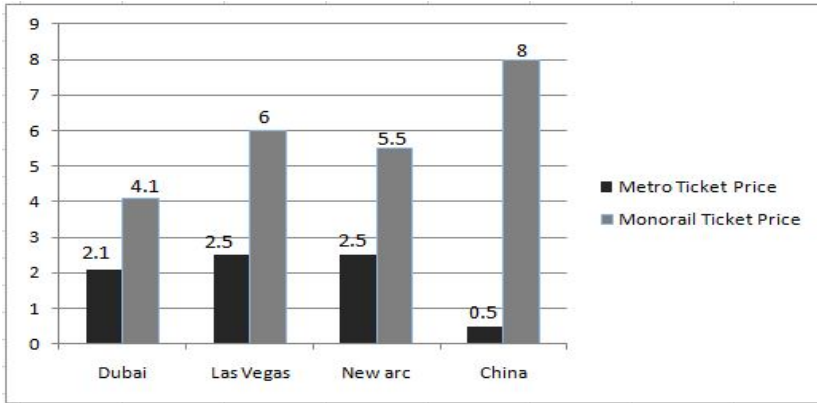


Figure 11: Sample extracted prices for 5 and 10 years investment for monorail in compare with metro.

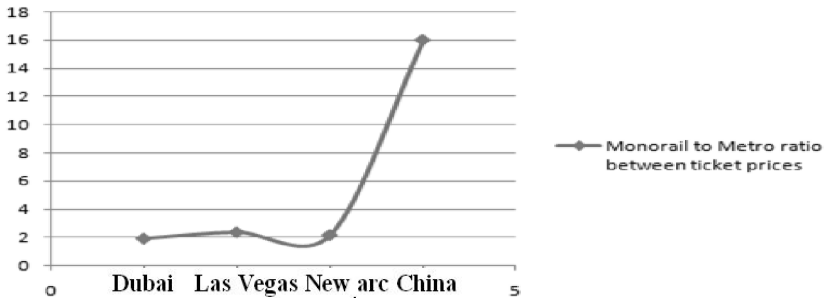


Figure 12: Ratio of Monorail to Metro ticket prices (RMM) in estimated cases for interpretation the function.

Figure 12 shall be applicable for the countries which have the meaning of subsidies program for their transportation. In the case of subsidies the price for monorail in these countries, the payback duration for the use of monorail as public transportation system should be more than 20–25 years, so obviously the private sectors will not be able for investment. Otherwise, for these cases, the original price could be used only for tourism and amusement parks. For instance, in Egypt, Alexandria or the attractive ancient historic sites and for Iran, Esfahan or Shiraz cities as the famous historic sites could be the answer and the results clearly show that, why in Tehran or Qom for pilgrims the Monorail system as public transportation system could not be acceptable and they were unsuccessful. Dubai monorail system shows a good consistency for the RMM due to its payback duration time.

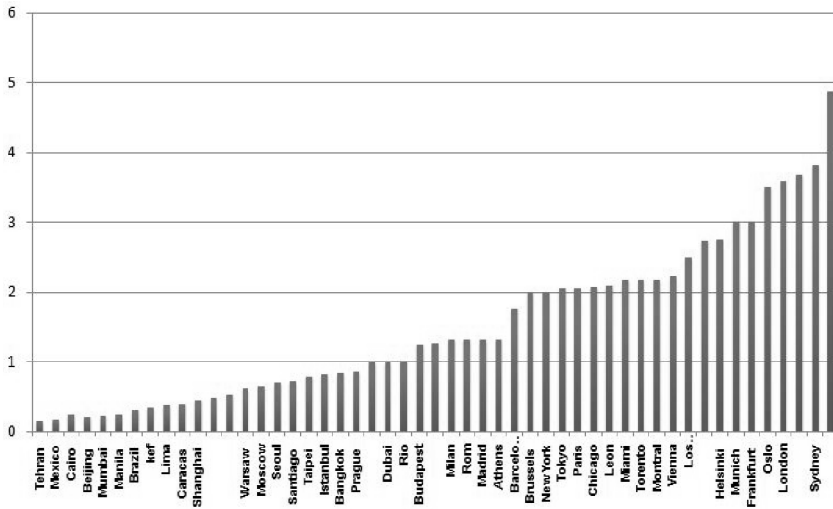


Figure 13: Metro Ticket price in deferent countries.

6 Conclusion

This study has found substantial regression for monorail trains to find the function between payback time, investment amount and thicket price and its ratio to metro price. The results show:

- Monorail system is to be a near ideal fit for advanced transportation in the countries with sound economies.
- Investment for monorail in developed countries or countries with sound economy could have the payback duration time between 5 to 10 years. So the private sectors will show their willing for investment.
- For the case studies in this paper (Egypt, UAE and Iran in Middle-East) the subsidies program for both Iran and Egypt will make a big deviation between metro and monorail ticket prices. Dubai metro and monorail ticket prices have a very good consistency to the global statistics.
- Comparison of Predicted and real prices in Iran and Egypt shows subsidies program. So public transportation will need long term payback for the monorail and hence a few private sectors will show their interests for investment.
- The other way for these countries is to subsidies the monorail ticket prices proportion to metro and other public transportation systems, however, for this system regarding to the number of passengers, it will not a reasonable way.
- Monorail system for these countries could be the way to increase the speed of construction for the short term policies.
- For the Middle-East countries with subsidies program for transportation sector, as the studied cases in this paper, monorail can use for tourism

purposes and for attractive sites such as historic and amusement parks. For example in Egypt, Alexandria or Cairo historic sites and for Iran, Shiraz and Esfahan as famous historic sites could be the answer for the real monorail ticket price. The simulation is similar to the Las Vegas monorail philosophy.

Acknowledgement

The authors would like to appreciate Mr Mustafa Mustafa Afifi Ammar (Heriot-Watt post graduate student) and Ms Sally El-Mistikawy from Heriot Watt University for their helpful information about Egypt.

References

- [1] Stone, Thomas J., et al. The Las Vegas Monorail: A Unique Rapid Transit Project for a Unique City, Narrative Report, 2001.
- [2] Maglift Monorail, A High - Performance, Low Cost, and Low risk Solution for High-Speed Ground Transportation prepared for Seattle, High Speed Ground Transportation Association, 1999.
- [3] Kennedy, Ryan R., Considering Monorail Rapid Transit for North American Cities, Narrative report, 2004.
- [4] National Iranian oil company, Comparative analysis between different model of transportation and effects of them on energy demand, National Iranian oil Company, 2002.
- [5] <http://www.ebtekarnews.com/Ebtekar/News.aspx?NID=63316>, 2011
- [6] <http://www.fardanews.com/fa/news/51293>, 2008
- [7] <http://www.ebtekarnews.com/Ebtekar/News.aspx?NID=32419>, 2011
- [8] <http://www.asriran.com/fa/news/106596/>, 2009
- [9] http://tehrooz.com/1390/7/17/TehranEmrooz/730/Page/11/TehranEmrooz_730_11.pdf, 2010
- [10] <http://www.atynews.com/fa/news/61485>, 2010
- [11] [http://www.saudi Gazette.com.sa/index.cfm?method=home.regcon and contentID=200804213890 and archiveissudate=21/04/2008](http://www.saudi Gazette.com.sa/index.cfm?method=home.regcon&contentID=200804213890&archiveissudate=21/04/2008)
- [12] http://www.wadhefa.com/news.php?news_id=82, 2010
- [13] The Monorail Society website – located at: www.monorails.org, 2010
- [14] [http://www.khaleejtimes.com/displayarticle.asp?xfile=data/middleeast/2009/September/middleeast_September2.xml and section=middleeast and col](http://www.khaleejtimes.com/displayarticle.asp?xfile=data/middleeast/2009/September/middleeast_September2.xml§ion=middleeast&col) 10, 2009
- [15] http://en.wikipedia.org/wiki/Dubai_Metro, 2011
- [16] <http://www.2daydubai.com/pages/dubai-metro.php>, 2011

