An investigation on the social and traffic effects of metro stations on neighborhoods

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Abstract

Neighborhoods within the hierarchy of urban structure are one of the smallest socio-physical building blocks of cities. Traditional neighborhoods of Iranian historic cities benefited from strong social relations which were flourished over the years and were manifested in the neighborhoods centers. In the modern era, the new master plans and the complementary local plans have disintegrated these neighborhoods both physically and socially. While old traditional neighborhoods were destroyed and new car oriented streets and highways have disrupted the traditional neighborhood life, the introduction of metro stations have provided a nucleus for neighborhoods around which urban space and social activity could emerge once more. In this respect, the attitudes of residents towards metro stations are very important. This study focuses on the social attitudes and the evaluation of traffic impacts of metro stations on adjacent neighborhoods. Therefore, the changes in traffic patterns as well as social characteristics and residential satisfaction levels in two neighborhoods adjacent to metro stations are studied through a questionnaire survey. The results show that despite the potentials provided, metro stations had adverse affects on both social integration and residential satisfaction levels. They also adversely affected neighborhoods in terms of traffic flow through increase in local traffic, demand for parking, and increase in noise pollution. Lack of attention to the new potentials turned them into threats and weakened the already damaged neighborhood structures..

Keywords: neighborhood, metro station, social effects, traffic effects, Tehran

1. Introduction

The aim of this study is to investigate the effects of recently introduced metro stations on the social and traffic dimensions of established urban neighborhoods and on residential satisfaction levels in Tehran. To achive this the neighborhood concept is explored and its development within Iranian cities is studied. Also a comparison of the characteristics of traditional neighborhoods of Iran with the modern and newly developed neighborhoods in recently developed areas is conducted. The effects of the layout of new street system and highways on physical function and social integration of old neighborhoods is studied as well.

Finally, introduction of various circulation and transportation networks including the metro system is discussed and is envisioned as a potential for re-strengthening the neighborhood system around the metro stations, a concept based on Transit Oriented Development theory and practice. This study is conducted to examine the advantage taken from such potential for the neighborhoods adjacent to metro stations.

The study is conducted based on survey questionnaire in two neighborhoods adjacent to the Sharif University and Iran University of Science and Technology metro stations in west and east of the city, respectively, along the same metro line. The number of subjects participated in the survey were 160 being equally distributed within the area of the two stations. These were used to study the effects of introduction of metro stations on adjacent neighborhoods in terms of both traffic consequences and social satisfaction.

2. The neighborhood as a spatial unit

The notion of neighborhood involves not only spatial proximity but also as a "district considered in reference to the

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character or circumstances of its inhabitants; a small but relatively self-contained sector of a larger urban area"[1]. Neighborhoods can be viewed as a set of actors, facilities, organizations, and the networks of association among them within a specified activity space. However, the geographical boundaries of such a set of associations can be hard to determine. The act of drawing these boundaries is ongoing and happens at many different levels.

Clarence Perry who introduced the concept of neighborhood unit development defines neighborhood as a component of a town which encompasses a five-minute walking radius from a center consisting of cultural uses including a primary school. Assuming a density of 10 families per acre, and a radius of about one-quarter of a mile, his neighborhood would occupy about 160 acres and encompass a total population of 5,000 to 6,000.

In the context of city planning, physical size is most often used to identify neighborhoods. The neighborhood can thus be defined as a physical entity of specific dimensions, as a grouping of a certain number of units or people, or as an area differentiated by social, cultural, or historical factors. Classical planning doctrines have sized the ideal neighborhood to fit an elementary school but according to Lynch (1981) such neighborhoods are themselves formed of smaller ones which are comprised of fifteen to thirty families and no more than one hundred households. Lynch makes a distinction between local districts defined as an identifiable residential area, neighborhood being a very small area within which people are acquainted, and community defined as a coherent social entity. For him the actual idea of neighborhood remains "at the scale of the very local unit, within which people are personally acquainted with each other in reason of residential proximity, where size, homogeneity, street pattern, identity of boundaries, and common services, may play a definite role in promoting control, present fit, and stability"[2].

Since the beginning of the century, the idea of neighborhood had many different meanings, from that of being a unit of social analysis used by sociologists to that of being a mere city block, and finally a self-sufficient spatial unit. With the rise of the urban renewal movement, neighborhoods have become issue-oriented groups with a specific political goal. Towards the end of the twentieth century, Lynch announced\ that the notion of neighborhood has evolved into a mere name, given to a particular section of a city with which people identify themselves with. More recently, the five minutes walking distance and then the quarter-mile walking radius have been expanded to a half mile with the addition of a transit hub as is proposed in the concepts of New Urbanism and Transit Oriented Development.

3. Iranian neighborhoods concept and development

Since ancient times, the concept of neighborhood was very important both in shaping and functioning of urban centers in Iran. In a simple definition, it comprises of adjacent housing located within a geographically defined space. Here, the term neighborhood refers to the smallest planning unit within the

city [3].

In a social definition, neighborhood is defined as "a place in which as residents enter into it, have the same feeling of being at home"[4]. Therefore, in lower income families whose private yards and gardens are too small, the streets and alleys of their neighborhoods are used by children, adolescence and elderly instead.

In a practical definition, neighborhood is defined as "the residential place of 700-1250 households (about 3500-6250 population) who are living within a 4 to 5 minutes walking distance of center"[5]. In this definition, the neighborhood contains several major elements such as primary schools and mosques, and such elements as convenient retail shops, parks and open spaces, sports and health facilities are also present.

4. The characteristics of a historical neighborhood

The manifestation of neighborhoods in Iran has gone through several developments, of which three stages are distinguishable; these include pre-Islamic era, Islamic era, and the contemporary era. The reasons behind formation of these homogenous and culturally bounded and physically united entities were different during history.

In pre-Islamic era, the cast system was promoting such internally homogenized yet externally distinctive settlement patterns called neighborhoods. The neighborhoods were major elements of the urban structure. During the Achaemenid Empire, the city was consisted of three zones; the inner zone was the governmental citadel, after which the middle city and the outer city were located. Within the outer city the residential neighborhoods, market place, gardens and even agricultural lands were located. During the next Dynasty, the Parthian, residential neighborhoods were located both in the middle and the outer city. While in the Sassanid period, the four major distinguished classes were housed within the middle city and the lower classes were residing in the outer city [6].

During the Islamic era, the disintegrated three parts urban entity of the pre-Islamic era was transformed into a unified entity. However, residential neighborhoods were still the basic structural units of the city. Their distinction was not based on socio-economic class distinction; rather it was based on the ethnic, religious, and regional affiliations.

The neighborhoods in the Islamic era were independent socio-physical entities each having their own encompassing walls, gateways to be closed at night for security reasons, and also their own urban infrastructure and facilities including mosques, local markets, schools, water basins and bath houses [7]. In some instances there were not only gateways towards the central parts of the city, but also gateways directly opening out of the city [6].

In the past, both in pre-Islamic and Islamic era, the neighborhoods were consolidated social units with high social transaction while they were also economically active. Therefore, while neighborhoods provided the functional needs, they were also psychological anchor points for the residents. These were social integrated entities with high levels of social interaction in which not only the physical needs of

residents, but also their psychological ones were well responded. Some of the main characteristics of old neighborhoods in Iran include high levels of residential place attachment, social integration, residential privacy and a functional and physical hierarchical system [8]. The physical structure of the city, access routes and the morphology of neighborhoods were important in creating these characteristics.

5. Changes in neighborhood structure during the contemporary era

During the last century, Iran went through a modernization process which was partially manifested in physical form within urban settlements. The most important of all were introduction of automobile and therefore, the necessity for provision of car access to old neighborhoods and developing new areas within cities with car access. Tehran sets an example of these new developments as Madanipour states that "The 1930s witnessed widespread road-widening schemes that tore apart the historic urban fabric, making them accessible to motor vehicles" [9]. Madanipour continues to explain that the aim was "unifying the space of the city, overcoming the traditional factional social structure, easing the movement of goods, services and military forces, strengthening the market economy and supporting the centralization of power." This in fact destroyed the physical fabric and autonomy of old neighborhoods as well as their social integration.

After the initial introduction of the new street system, a more systematic attempt was conducted to restructure the city through official master plans. Tehran's Master plan was proposed and approved in 1968 as an almost pioneer plan in Iran in which a new neighborhood structure was defined for the city. This was based on a hierarchical system of urban structure in which the smallest units were neighborhood of 5000 inhabitants focusing on a neighborhood centre and a primary school.

Within this new urban structure, "districts and areas would be linked by a transportation network, which included motorways, a rapid transit route, and a bus route. The stops on the rapid transit route would be developed as the nodes for concentration of activities with a high residential density"[9]. In this plan both concentration of activities and high residential density is envisioned.

The concepts proposed here were very similar to the Transit Oriented Development concept which has been proposed systematically later on. In TOD concept, mixed use and high density development, connection to public transit systems, and attention to design features such as human scale, walkability, and accessibility to various buildings are proposed [10]. In general transit-oriented development should promote walking and transit riding and discourage automobile use. This should enhance mobility and environmental quality, increase public safety and result in neighborhood revitalization [11].

It is assumed as stated in the proposals of Tehran's master plan that introduction of metro stations provided an opportunity for socio-physical reconstruction of neighborhood structure. It is expected that through the concentration of housings, jobs, shops, and other activities around transit stations as well as improved accessibility to these varied land uses, the neighborhood environment is enhanced. Also as in TOD concept, a higher safety is expected due to continual presence of users and activities. Improved environmental quality such as noise pollution is expected when movement patterns are changed to walk and ride, instead of park and ride and or provision of appropriately designed parking.

Acknowledging the impact of transportation networks on socio-physical transformation of neighborhoods, this study is conducted to examine the results of introduction of the metro system and its stations. This is achieved through measurement of neighborhood residential satisfaction with social and traffic indices after commencement of metro stations.

6. Selection of case studies

To select the metro stations for the case study, all stations along line 1 and line 2 (the two working lines) of Tehran metro system were studied in detail considering the following characteristics.
- not located within CBD
- not located within traffic prohibited zone
- being located within a neighborhood
- availability of data and maps
- providing local level service

The results of the study show that several stations including, Tarasht, Khazaneh, Sharif and IUST are good cases for conducting this research. Among these, Sharif as well as Iran University of Science and Technology station were selected as two comparable neighborhood stations.

7. Pilot study

In this study we examined how far the introduction of metro systems and their stations can accomplish the aims mentioned above and their end results. At first a questionnaire was developed based on the theoretical framework of the characteristics of a good neighborhood and also to measure the social and traffic effects of metro stations on neighborhoods.

A pilot study was conducted using 60 questionnaires which were distributed equally within the 300 meter radius of both metro stations. A Likert scale of 1 to 5 was used in which initial analysis of the data using SPSS program showed that there is a tendency to choose the middle option of the scale. Therefore, the final questionnaire was using a Likert scale of 1 to 4 to eliminate the middle range. The results were employed to determine the sample size.

8. Sample size

Using the pilot study data, the sample size was determined based on Cockran formula through Alph Cronbach coefficient and variance. Here, the variance is 0.3025 and spd = 0.12. Therefore, to achieve data with a confidence level of 90%, a sample size of 160 is needed to participate in the study.

$$n = \frac{2^2 * z_{\alpha/2} * \sigma^2}{spd^2} \qquad (1)$$

9. Data analysis and hypothesis testing

A set of 160 questionnaires were distributed equally and randomly among the residents of the neighborhoods adjacent to the metro stations. For this study, half a mile or 800 meter radius was considered as the walkable zone around the metro stations. This was based on the results by Untermann (1984) on walking behavior which shows that 2,300 feet is the maximum distance people are willing to walk for general purposes [8].

The data were analyzed using SPSS version17. The correlation analysis among variables was conducted using Chi square for nominal data and Gamma for rank ordered data. Since the aim of this article is to measure the traffic consequences and social effects of metro stations on neighborhoods, two major hypotheses were developed which examined the effects of social and traffic indices after establishment of metro stations and their correlation with satisfaction levels.

10. Testing hypothesis

Hypothesis 1

o examine the effects of establishment of metro stations on social characteristics of neighborhoods, three groups of indices are considered including presence of non-locales, level of security and sense of place attachment. Before investigating the correlation between these variables, the distribution characteristics of the social variables are examined.

Investigation on the mean and median of social characteristics indices presented in table 1 shows that the mean of "effect of metro stations on presence of undesirable social groups" is highest among all the indices and the means for "satisfaction with neighborhood social transformations after metro stations"', "effects of metro stations on presence in neighborhood space" and " effect of metro station on day time security" are setting afterwards. The mean for "attachment to neighborhood space after establishment of metro station" is the lowest of all.

The median shows that "satisfaction with social transformations of neighborhoods due to establishment of metro stations", and "effects of metro stations on presence of undesirable social groups", was rated "low" by over 50 percent of respondents. Also "satisfaction with and attachment to neighborhood space after establishment of metro stations" was rated "very low" by over 50 percent of respondents. They also rated their "satisfaction with presence of non-locales within the neighborhood space as "very low". The majority believed that the "effect of metro station on presence in neighborhood space", " social control" and "night time security" is "very low" as well.

In order to examine the correlation between the ranked ordered data, Gamma statistics is used, while examining the relation between ranked data and categorical data (e.g. sex and occupation) was conducted using contingency tables. The results are shown in table 2 which shows a significant correlation between social characteristics and "satisfaction

Table 1. Distribution Characteristic of the Social Variable

Index	Mean	Standard Deviation	Median
Social desirability of introduction of metro	1.69	0.574	2
Satisfaction with neighborhood	0.72	0.574	1
Presence of non-locales	1.14	0.762	1
Presence of undesirable groups	1.76	0.754	2
Social control	1.19	0.641	1
Daytime security	1.31	0.756	1
Nighttime security	1.2	0.671	1
Presence in neighborhood	1.48	0.674	1
Attachment with neighborhood	0.47	3.192	1

level with establishment of metro stations".

As the results show, highly significant correlations between all neighborhood social characteristics and "satisfaction level with establishment of metro stations" are observed except for "attachment with neighborhood". This shows that the issue of attachment with neighborhood must be related to other and more important factors besides accessibility and other aspects related to metro stations. But in terms of the importance of the neighborhood social characteristics, these could be compared through gamma statistics which shows the hierarchy of the correlation of the social indices by satisfaction level with establishment of metro stations

The results show that the presence in neighborhood space was the most related index with a correlation coefficient of 0.649. The day time security and presence of undesirable social groups are the next indices with coefficients of 0.561 and -0.533, respectively. The negative correlation of undesirable social groups and satisfaction level with metro stations show that as the presence of these groups were perceived higher, the satisfaction with metro stations is diminished. The social control dimension and night time security in neighborhood spaces are third rank indices with coefficients of 0.497 and 0.482, respectively. The presence of non-locale groups is the least related index with correlation coefficient of 0.325.

A further analysis of the correlation between the presences of non-locales with satisfaction level with metro stations is conducted through a contingency table. The results show that over 70 percent of respondents did not like presence of non-locales in the neighborhood spaces and have rated it low or very low.

Also the results of table 3 shows that three indices of environmental security including social control, day time security, and night time security have a significant correlation with satisfaction with establishment of metro stations. In other words from the view point of the residents, an increase in security have increased satisfaction levels with metro stations.

The results of the effects of personal characteristics on social indicators are presented in table 2. The summary is as follows:
• Men and women have a different understanding of the social characteristics.
• Different age groups have a different understanding of social characteristics

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Table 2. Correlation analysis of "social characteristics" with "satisfaction with establishment of metro stations" and personal characteristics indices

	Index	Satisfaction level with establishment of metro stations		Gender	Age	Education	Occupation	Length of residence	Distance from station
		Sig	Value	Sig	Sig	Sig		Sig	Sig
Presence of non-locals	Presence of undesirable social groups	0.000	-0.533	0.920	0.077	0.446		0.499	0.138
	Presence of non-locales	0.015	0.325	0.014	0.402	0.255		0.443	0.707
Environmental security	Social control	0.000	0.497	0.015	0.449	0.920		0.409	0.726
	Daytime security	0.000	0.561	0.207	0.293	0.287		0.531	0.489
	Nighttime security	0.000	0.482	0.231	0.336	0.882		0.749	0.722
Other characteristics	Presence in neighborhood space	0.000	0.649	0.010	0.113	0.989		0.936	0.168
	Attachment with neighborhood	0.163	-0.206	0.021	0.017	0.756	0.000	0.742	0.982

The gamma statistics shows that the hierarchy of the correlation of social indices by satisfaction level with establishment of metro stations is as follows:
The presence in neighborhood space was the most related index with a correlation coefficient of 0.649.
The day time security and the presence of undesirable social groups are the next indices with coefficients of 0.561 and -0.533, respectively.
The social control dimension and night time security in neighborhood space are the third rank indices with coefficients of 0.497 and 0.482, respectively.
The presence of non-locale groups is the least related index with correlation coefficient of 0.325.

• Occupation affects their understanding of social characteristics.

Since gender significantly affected the evaluation of social characteristics of neighborhoods, a separate correlation analysis was conducted for each group using split file to distinguish the differences of correlations between neighborhood social characteristics and satisfaction with metro stations from a gender point of view (Table 4).

The results show that there are many significant correlations between social characteristics and satisfaction with establishment of metro stations from women's point of view, while men were less sensitive to social characteristics and their relations with satisfaction with establishment of metro stations.

For women, presence of undesirable social groups had a stronger negative correlation with satisfaction level with establishment of metro stations than for men. While presence of non-locales was correlated with satisfaction levels in a positive manner for women, it was not significantly correlated from men's point of view.

It must be noted that women showed a positive correlation of the day time security, night time security and social control in neighborhoods with satisfaction of metro stations. While for men only day time security was correlated with satisfaction level with establishment of metro stations. Attachment to neighborhood was a social character unrelated to satisfaction with establishment of metro stations for both groups.

Hypothesis 2

Table 3. Presence of non-locales in the neighborhood

		Very high	High	Low	Very low	Total
Satisfaction level with establishment of metro stations	Very high	2.6%	13.1%	21.6%	5.2%	42.5%
	High	2.6%	8.5%	34.0%	12.4%	57.5%
	% from total	5.2%	21.6%	55.6%	17.6%	100.0%

Table 4. Social characteristics and satisfaction with metro stations based on gender

	Satisfaction level with establishment of metro station	Women		Men	
		Sig	Value	Sig	Value
Presence of non-locals	Presence of undesirable social groups	0.000*	-0.656	0.011*	-0.438
	Presence of non-locales	0.020*	0.515	0.198	0.233
Environmental security	Social control	0.000*	0.761	0.112	0.306
	Day time security	0.002*	0.608	0.002*	0.526
	Night time security	0.000*	0.714	0.126	0.285
Other characteristics	Presence in neighborhood space	0.002*	0.652	0.000	0.643
	Attachment to the neighborhood	0.497	0.171	0.300	-0.397

Table 5. Traffic characteristics in neighborhoods adjacent to metro stations

Index	Mean	Standard deviation	Median
Local traffic	2.48	0.644	3
Curbside parking	2.95	0.246	3
Noise pollution	2.46	0.690	3
Safety of movement	1.69	0.574	2

First an analysis of the effects of metro stations on such traffic characteristics as local traffic, curbside parking, noise pollution and movement safety is conducted. As it is shown in table 5, the mean effect of metro stations on curbside parking is higher than other indices. Next stands the effects of metro stations on local traffic, noise pollution, and finally on safety of movement. Also, the analysis of standard deviations shows that while curbside parking is defined as being most affected by establishment of metro stations, there is also the highest congruity among respondents for this index. On the other hand, the congruence on the effects of metro stations on noise pollution is the least among the other measures between respondents. This may be due to the intermediate effect of distance from metro station on level of exposure to noise pollution.

The analysis of the median of these four indices shows that over 50 percent of the respondents have evaluated the effects of metro stations on local traffic, curbside parking, and noise pollution as high while its effect on safety of movement was evaluated as being low.

In this hypothesis, the relation between "satisfactions with metro stations" and traffic characteristics are analyzed. For this purpose, both gamma statistics and contingency tables are used as appropriate with data type. As it is shown in table 6, all the indices of traffic characteristics have significant correlations with satisfaction with metro stations, except for the curbside parking which did not show a significant correlation. This shows that despite accepting the

increase in local traffic and noise pollution, residents are still satisfied with establishment of metro stations. Also, they see a positive correlation between establishment of metro stations and safety of movement.

Summary of the results are:
• Men and women have a different perception of the effects of metro stations on curbside parking while they agree on its effects on other traffic indices. This may be related to differences in car ownership patterns among men and women
• Different age groups and people with different education levels have a similar understanding of the effects of metro stations on traffic indices.
• Occupation and length of residence do not have any effect on evaluation of traffic indices.
• Only distance from metro station is positively correlated with levels of noise pollution.

11. Discussion

Data analysis investigated the correlation between satisfaction with establishment of metro stations with two major factors of social and traffic characteristics which were measured through some indices. Also, the relation of personal characteristics measured through six indices including gender, age, education, occupation, length of residence, and distance from the metro station with social and traffic indices were examined.

The results show that while there was an overall satisfaction with establishment of metro stations, there was also a positive correlation between satisfaction with metro stations and increase in traffic levels and some social characteristics including presence of non-locales and increase of security. At the same time, wherever residents were not satisfied with metro stations, there was an increase in levels of through traffic, noise pollution, lack of safety in movement, and also there was an increase in the presence of non-locales and lack of security in social terms. Therefore, there are some strategies suggested to reduce the social and traffic effects of metro on its adjacent neighborhoods (Table 7).

12. Results and conclusion

The issue of transportation was one of the most important issues in Iranian modern urban development, one which through introduction of new street system and even more recent highway system has disrupted the traditional structure

Table 6. Correlation analysis "traffic characteristics" with "satisfaction with establishment of metro stations" and personal characteristics indices

Index	Satisfaction with metro station		Dender	Age	Education	Occupation	Length of residence	Distance from station
	Sig	Value	Sig	Sig	Sig	Sig	Sig	Sig
Local traffic	0.000	0.710	0.409	0.381	0.736	0.146	0.326	0.506
Curbside parking	0.239	0.555	0.096	0.842	0.966	0.726	0.322	0.302
Noise pollution	0.000	0.606	0.441	0.424	0.515	0.15	0.658	0.094
Safety of movement	0.000	0.713	0.610	0.112	0.809	0.119	0.659	0.115
Access	0.000	0.844	0.613	0.700	0.239	0.319	0.218	0.499

The gamma statistics shows that the hierarchy of the correlation of the traffic indices by satisfaction level of establishment of metro stations is as follows:
Satisfaction with metro stations has is significantly correlated with with access with a correlation coefficient of 0.844.
Satisfaction with metro stations is correlated with both safety of movement and local traffic with Gamma coefficients of 0.713 and 0.710, respectively.
Satisfaction with metro stations has the least correlation with noise pollution at a correlation coefficient of 0.606.

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Table 7. Social and traffic oriented strategies for reducing the effects of metro on adjacent neighbourhoods

Traffic oriented strategies	Social oriented strategies
Enhancing safety and reducing accidents	Providing possibility for presence of various social groups in neighborhood's public spaces
Reducing through traffic	
Control of curbside parking in neighborhoods	Increasing day time and night time security
Reducing permeability and legibility of neighborhoods for non-locales	Increasing the level of trust between people and also people and institutions
Segregation of vehicular movement from pedestrian and cyclists	
Reducing temporary traffic jams	Increasing the opportunity for social participation
Improving the quality of change of trip mode in metro stations	Increasing sense of citizenship
Providing movement for people not owning cars	
Integration of pedestrian and biking routes within neighborhoods	
Improving the public transit networks connecting neighborhoods	

of neighborhoods. In response to the lack of an efficient public transit system, metro system was introduced. This could have enhanced not only mobility and accessibility but also environmental quality. It also could have changed travel patterns from park and ride to walk/bike and ride. These could have been used towards strengthening the neighborhood structure.

Despite improving access and mobility, neither traffic objectives were achieved nor environmental improvements were observed. A strong social transformation to increase the sense of attachemtnt to neighborhoodo was not achieved either. Therefore, an opportunity to reorganize, revitalize, and re-structure neighborhoods was lost

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