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Assessing Effects of Public Transport Oriented Development in Cities (Case Study: Chitgar Station of Tehran)

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Abstract-Although transport in cities has long been a concern for urban planners, the unprecedented increase in urbanization and the emergence of numerous means of transportation after the Industrial Revolution has greatly increased its importance. Since then, urban transportation has become one of the greatest challenges in urban planning worldwide. The impact of urban rail networks on urban land development is not linear, but the related structural planning has great influence on population absorption and the potential physical, social and economic development of regions. Therefore, the growth and control of such regions is possible. The objective of this article is to evaluate the effects of public transport system development on the physical, social and economic structures of cities. Information was collected from previous research and documented studies, and from interviews achieved with a designed questionnaire. The studied group consisted of citizens living near the Chitghar subway station in Tehran, station subway in Chitghar station of Tehran. Study participants were asked about the physical, social and economic impact of TOD on their daily lives. This research used a variety of methods to examine the beneficial impacts of Transport Oriented Development (TOD) and development near stations, including qualitative and quantitative approaches and data collection. Questionnaires were distributed between survey distributions to citizens living near the station. The secondary data was analyzed by SPSS22. The results of this study indicated that development surrounding public transport routes and terminals emphasize activities and necessities such as walking, cycling, public lighting, public security on the streets, job creation and other factors which affect life near subway stations. Thus, public transport oriented development can be categorized into physical, social, and economic indicators in cities.

Keywords- *Public Transport Oriented Development; Physical Organization; Economical Organization; Urban Transport; Social Organization*

I. INTRODUCTION

One of the most important challenges facing large cities and provincial capitals in the present day is transportation. Transformational activities over the past forty years worldwide indicate increasing dependence on cars and significant social lifestyle changes. This in turn has created increased sensitivity to the environmental impacts of transportation and the related repercussions on human health [1]. A lack of standardized criteria influenced by the market system, transportation systems and traffic flows have created problems in urban environments, and a significant portion of city budget funds are spent on mitigation and relief, rather than addressing the roots of transportation problems.

Previous research indicates that TOD inhabitants drive less than those living in non-transit-supportive places [2-4]. The population density, mix of uses and relative accessibility allows inhabitants, including workers and visitors to achieve their daily obligations without driving. The result of a research reported that many TOD ridership profits are the result of self-selection, individuals who chose their place of residence in order to be close to public transit resources. Travel records of California inhabitants indicate that nearly 20% of people living within one-half mile of public transit used transit resources to travel to work, as compared to less than nine percent of those who live more than one-half mile from a public transit station [4]. However, this depends upon the assumption that people who want to drive less can choose to live in transit-accessible places. If this is true, then self-selection into a particular geographical area could bias the statistical results. However, recent research that has sought to control for self-selection bias has reported that the effects of self-selection are small, and that the statistical associations are still considerable [5]. Thus, despite any self-selection prejudice, TODs can effectively reduce vehicle travel. Chatman reported that residents who value accessibility most may be most set in their ways; that is, they may already take advantage of public transit, while those who value accessibility least are more likely to change their established mode of transportation if they live in a TOD. Thus, self-selection could underestimate the impact of TODs on trip manner [6]. One potential effect on trip manner is the impact of TOD on vehicle miles traveled (VMT), which leads to a reduction of energy demands and reduced demands on the road network, inducing economic and environmental benefits [7]. The result of a research investigated whether VMT reduction is the result of the simple presence of transit options, such as rail and bus, or if land use plays a significant role. They report great differences in the effects of proximity of trip manner. The investigation of average regional features of the built environment may also obscure many of the more localized impacts that affect individual travel decisions [8].

Economic influences and benefits can be distinguished by whether such impact affects people, residents, communities, districts, or particular firms. Mounting evidence indicates that living in transit-supportive places results in lower total expenditure on the two largest household expenses: housing and transportation [9]. Additionally, the health benefits related to more walkable neighborhoods has been previously documented, though not necessarily in relation to TODs [10]. There are a number of potential health impacts that can be derived from TOD projects; however, in many circumstances, the specific design aspects and qualities of the TOD may have great influence on these health effects and their magnitude. For example, TODs may be located in or near major centers of activity, or located further away on the edges of such centers of activity. This could greatly influence the likelihood of residents to own cars, the level of ambient air pollution and the attractiveness of transit access. The type and function of the transit station (e.g., park-and-ride, terminal for feeder bus service) may also influence the health benefits provided by TOD. A short report is presented to describe the effects of each potential health impact, in addition to means of measuring the potential health effects of TOD.

TOD is anticipated to result in more nearby destinations that can be accessed by walking and bicycling. While the relationship between the environment and walking has been clearly established, only more recently has research specifically tested the use of transport as a potentially related to walking. Since the use of public transport often includes walking to and from the mode of transportation, this relationship makes intuitive sense. Dannenberg, et al., and Lee and Moudon identified the necessity to investigate the correlation between the use of transport and walking with greater specificity [11, 12]. A number of researchers have discovered a relationship between the use of public transport and physical activity, particularly the action of walking.

Research provided by the National Household Transportation organization indicates that transit users spent an average of 19 minutes per day walking to and from transit modes, and that approximately one-third of those cases met physical activity recommendations (walking five times per week for approximately 30 minutes or accumulating 150 minutes of physical activity per week) simply by walking to and from modes of public transportation [13]. Travelers are also likely walk more in order to access neighborhood services, which is supported by TODs with strong land-use-mix components.

Links have been identified between the use of public transport and physical activity, whether or not inhabitants live in a TOD. It has been reported that travelers who live in places with high and low walkability are more likely to walk more than non-users of transport. The difference in frequency of use between users and non-users was greater in areas of low walkability. Transit commuters were also more likely to walk in order to access stores, markets, banks, post offices, and other services located near their home or their workplace [14-20].

The increase in physical activity associated with the use of public transit has also been correlated to beneficial health outcomes. One study reported that additional minutes spent walking is translated into energy and expenditure and a reduction in the prevalence of obesity. According to this potential reduction, a present savings of \$5500 per person was calculated, and suggested that the quality of life could become even higher [21-23].

Portney explored the relationship between civic engagement and social capital, and reported that urban inhabitants more engaged in sustainability processes tend to be more participatory [24]. In terms of the social capital within a community, research has also reported that compact, mixed-use development can create feelings of closeness to one's community. A study of the inhabitants of Galway, Ireland, indicated that people living in more traditional places felt more closely related to their community as compared to people living in more modern places, and that those living in the traditional environments were also more likely to know their neighbors and more likely to trust other people [25, 26].

The three primary environmental effects associated with driving are air pollution, greenhouse gas emissions, and noise pollution. Greenhouse gas emissions, primarily CO₂, are closely linked to climate change. In order to reduce greenhouse gas emissions, the promotion of TOD can be employed to double transit ridership. Noise can also be regarded as a health effect with negative impact on quality of life [27]. The health effects of road traffic noise have been well reported, and are generally regarded as stress-related. TOD regions with safe street design for pedestrian use can result in slower traffic speeds and decreased traffic noise as compared to noise created by traffic moving along highways [28, 29].

The purpose of this paper is to assess the impact of development based on public transport systems on the physical, social and economic structures of cities. Effective indicators are then discussed, with an emphasis on walking and public transport oriented development, and results are then analyzed. With an emphasis on walking and public transport oriented development are discussed and in the end the results were analyzed.

II. IMPORTANCE OF TRANSPORT ORIENTED DEVELOPMENT

There is considerable evidence that residents of TODs drive less than residents living in non-transit-supportive locations [4, 5]. The population and destination density, mix of uses and relative accessibility allows residents, including workers and visitors, to fulfill their daily needs without driving. One potential impact on travel behavior is the effect of TOD on vehicle miles traveled (VMT). Reductions in VMT result in lower energy demands and reduced demands on the road network. Lower energy demands provide economic and environmental benefits while reduced demand on the road network can result in lower long-term investment needs. The impact of TOD is further discussed in the following sections.

III. THE IMPACT OF PUBLIC TRANSPORT ON URBAN DEVELOPMENT

Trajectories that take the structural shape of cities into account as well as the development of surrounding areas plays a significant role in urban public transport development. The growing population concentrations in cities and the expansion of public transportation systems induced by the Industrial Revolution has created numerous perspectives surrounding the development of cities according to the potential elements of urban transport situations.

Although development around public transport routes and terminals are taken into consideration, various objectives and methods have been proposed. Development based on public transportation has been emphasized in recent years, including characteristics such as design improvement of neighborhoods, reduced car use and increased walkable areas [30].

IV. DEFINITION OF DEVELOPMENT BASED ON PUBLIC TRANSPORT

The concept of development based on public transport as incorporated into planning and urban design appears to indicate strategic common sprawl and smart growth. Dietmar and Patyka defined public transport development as a mixture of land uses with different densities within one-half mile of a transit station. Steel defined public transport development as a social structure with mixed performance that encourages people living nearby to take advantage of public transportation options and reduce reliance on the use of private cars.

Parker defined public transport development as the medium-to-high density development along a transit path that includes an easy walk to a station with a mix of residential, employment, and pedestrian opportunities. According to this definition, the presence of cars in the environment is less encouraged, and walking is emphasized. According to Kalthorp, public transport development contributes to high-density residential and public uses, jobs, retail locations and services concentrated together within strategic locations in transport area systems [31].

V. EFFECTS OF PUBLIC TRANSPORT ORIENTED DEVELOPMENT ON THE CITY

Public transport oriented development that provides access to needed public transport reduces the use of private cars and thus saves investments in roads and parking by reapplying the land in beneficial ways. The use of public transport also saves travel costs for passengers. Public transport oriented development provides walking and cycling opportunities for the accomplishment of daily tasks and reduces distance of car travel as well as use of personal vehicles, in turn reducing traffic in cities and subsequently improving urban air quality [32]. Successful development with a focus on public transport can significantly reduce motor vehicle use. Public transport oriented development reduces round trip transportation costs per day for single passenger vehicles by 22/5% and increases non-motorized and public transport use by 27%.

Patterns of land use at the beginning and end of a trip have a significant impact on travel behavior. Workers in areas with a high density of employment, favorable conditions for hiking and attractive urban environments with shops and restaurants are more willing to commute by public transport every day. In fact, public transport oriented development relies on public transportation and urban development near public transport centers and stations [33]. The goals of public transport oriented development include walkability, the creation of pedestrian-oriented environments and the creation of attractive settings for pedestrians accomplished by the design, scale, and quality of buildings and the urban landscape [31].

VI. METHODS AND MATERIALS

This research employed a variety of methods to examine the beneficial impacts of TOD and urban development near transport stations, including qualitative approaches and data collection. Questionnaires were distributed between survey distributions to citizens living near the studied station.

The sample targeted 384 randomly selected households at various sites around the transport station, divided into the following categories: households located within one-half mile of Chitghar station, households in new or substantially renovated areas within one-quarter mile of Chitghar station, and households located between one-half and two miles from Chitghar station (Fig. 1). Various transit lines were also investigated, and secondary data was analyzed by SPSS22.



Fig. 1 Map of subway lines in Tehran

VII. RESULTS AND DISCUSSION

Each person uses TOD for personal reason. Cranford selected this type of regrowth as representative of progress and to build dwellings for inhabitants who wish to remain in the area once single-family homes are no longer necessary to their family needs.

Some towns have begun to shift toward a popular transport-oriented civic development model with increasing use of non-mechanized modes of travel as a result of socio-demographic change, changing public opinion, strong political leadership and technological innovation.

Transportation is one of the greatest sources of carbon emissions in towns. The transport sector typically utilizes nearly 23% of energy-related CO₂ emissions worldwide, which was equal to 6.7 giga tons of CO₂ in 2010 [34]. While urban car use is the single greatest contributor to transport carbon emissions, freight transport accounts for up to 20% of civic traffic and up to 50% of civic transport GHG emissions [35]. Additional life cycle analysis recommends that carbon emissions resulting from transport infrastructures are substantial, typically contributing an additional 63% for on-road and 155% for rail transport situations to emissions from vehicle performance. Emissions are increasing more rapidly in the transfer sector than in any other, and are forecasted to increase by 50% by 2035 and to nearly duplicate by 2050 under a business-as-usual framework [34, 36].

The primary social benefits of this system and the creation of complex system components include job creation, which is one of the greatest problems facing developing countries. Alternatively, by easy access of various parts of the city, class differences are reduced and social welfare is raised. In order to slow the growth of investment in public transport, the establishment of transport complexes will result in greater willingness from governments to invest in public transport due to the attraction of additional capital.

Additionally, growth in the value of the land around transport stations provides another economic benefit to the establishment of transportation complexes. As work on the complex begins, the value of the land surrounding the station increases. As a result, the growth of revenue from the tax of such complexes will increase, with the revenues eventually being returned to the economic system. This system will also create incentive to decrease personal vehicle use.

Physically, the development of transport complexes will help protect the environment and reduce pollution by decreasing the volume of trips within the city and increasing use of rail transport systems, such as subways. In addition to the impact of transport systems on the natural environment, this system will greatly affect land use and land value.

This potential impacts of the proposed system not only alters user patterns but also increases the quality of life and the value of properties adjacent to the transport stations. The benefits of organizing physical, social and economic life by public transport organization can be examined from the economic, physical, transport management, environmental and social perspectives, which are further discussed in the following sections (Table 1).

TABLE 1 EFFECTS OF PUBLIC TRANSPORT ON INDICATORS (SOURCE: AUTHORS)

| Physical | Transport management | Economic | Social | Environmental |
|--|--|--|---|--|
| Combining policy of land use with public transport will reduce the per capita land area needed for other means of transport in the city, and thereby reduce the number and the per capita levels, while the number of users of cultural sports and services will increase. | <ul style="list-style-type: none"> - Convenient facilities for pedestrians - Right cobblestone - Vegetation cover - Lighting - Game vehicle - Create conditions for bicycling - Improve access to public spaces such as squares and parks | <ul style="list-style-type: none"> - Increase investment in public transport - Increase value of land around the station | <ul style="list-style-type: none"> - Improve access to retail services and recreational and cultural opportunities - Improve public health and safety on the street | <ul style="list-style-type: none"> - Improve air quality and reduce gasoline consumption - Reduce congestion |

After examining the effects of development on public transport and related criteria, numerous theories related to urban transport have been compared to determine the impact of public transport development on various indicators (Table 2).

TABLE 2 THEORIES RELATED TO URBAN TRANSPORT [35]

| Related measure | Concept | Title of theory | Theorist | Period of time of presenting theory |
|---|--|---|--|-------------------------------------|
| Predict the location of the parking, play areas and walkways over the streets | Create harmony between pedestrians and vehicles on neighborhood streets with speed limits and movement of the vehicles | Vonfer's pattern with traffic reduction | Nick de Boer | 1960-1990 |
| Create a range of auto-focus circuits around public transport stations, make use of trade-office investment by governments around public transport stations. | Development around public transportation stations in order to achieve maximum economic return. | Transport related development (TRD) | Peter Kaltroop Shelly Butija | 1985-1995 |
| Sustainable features including public transportation, walking, riding, electric and dual-transit car technology and rapid public and private transportation, and other green transport options. | Transportation systems, which do not threaten public health or life and meet transportation needs, including less use of renewable and non-renewable resources. | Sustainable transportation (SD) | Organization for economic cooperation and development (OECD) | 1990-2000 |
| Mixed land use creating pedestrian-oriented neighborhoods, providing a variety of transportation options, and directing development toward existing communities. | Development based on mass public transportation and limited environmental impacts, derived from the concept of sustainable development. | Smart growth (SG) | Stephen Bloden Andreas Dwani | 1990-2000 |
| Combination of two new approaches of rail systems and urbanization in the U.S., comprising four principles: public spaces around centrality of terminal station leads to communication facilitation with other parts of the city center and public spaces around gas play a major role in celebrations. | Transit villages based on a combination of principles of urban design, transportation and economy by creating intensive social and walking areas around a public transportation station. | Transit villages (TV) | Michael Bernice Robert Serouro | 1995-2005 |
| Rail Terminals are a prominent characteristic of city center with the maximum pedestrian-priority, transportation systems support collectors, reduced and managed parking spaces around sidewalks around the terminals. | The creation of compact communities with centered sidewalks on high-quality rail systems. | Transport oriented development (TOD) | Peter Kaltroop Hank Dittmar Gloria Ahland | 2000-2010 |

After evaluating numerous studies, development indicators were determined and compared based on public transport. Indicators were extracted and analyzed by SPSS to determine the proposed criteria (Table 3).

TABLE 3 T-TEST VALUES OF INDICATORS (SOURCE: AUTHORS)

| | Test Value = 3 | | | | | |
|----------------------|----------------|----|-------------------|-----------------|---|-------|
| | t | df | Sig. (two-tailed) | Mean Difference | 95% Confidence Interval of the Difference | |
| | | | | | Lower | Lower |
| Social | 4.548 | 98 | .000 | .37500 | .2700 | .5211 |
| Economic | 4.757 | 99 | .002 | .41361 | .2172 | .5770 |
| Structural | 2.756 | 98 | .000 | .26073 | .2222 | .4999 |
| Environmental | 3.676 | 97 | .000 | .35789 | .1103 | .3500 |
| Walkability | 3.623 | 98 | .000 | .31429 | .0812 | .3308 |
| Security | 2.921 | 99 | .002 | .20570 | .1908 | .4993 |

Test results indicate that the significance level of all tested cases was below 0.05. Statistical significance for the economic factor was $p=0.002$ and that of the security factor was $p=0.002$. Significance levels of the social, physical, environmental, and walkability indicators were $p=0.000$. According to the results, the hypothesis is accepted.

VIII. CONCLUSIONS

The primary conclusion of the current study is that increased development near train stations in Tehran can lead to a wide range of benefits for transportation users, residents of the area, and the municipality that develops TODs. These benefits include increased interaction among neighbors and those within the community, more walking activity with subsequent health benefits (although the analysis of self-reported health was inconclusive), less driving and reduced pollution and other costs, and increased tax revenue for the municipality derived from increased property values. Safety benefits can also occur, but would require the creation of safe and walkable areas for pedestrians, which was strongly reiterated by focus group participants. The difficulty of attracting a greater variety of practical retail establishments to areas around stations was regarded as a deficit by residents, and a challenge to planners and developers. Overall, the present study contributes to current understanding about the benefits of TOD and development near transport stations. Moreover, these findings validate the need for further investigation of targeted redevelopment near transportation stations.

The results of this study indicate that the economic impacts of transport stations influence the surrounding spatial organization near metro stations and can result in improved access to residential and commercial areas, as well as city services, leading to cost and time savings. Properties adjacent to stations can take advantage of the economic benefits by investing in the construction and maintenance of rail transport with the increased profit. Urban rail transport networks are important tools of economic growth and development. Smart city development integrates land use and transport system development to minimize the demand for travel, resulting in centralization around urban subway or train stations. This effect was particularly apparent in the areas surrounding train stations, and over time, each station creates attractions that are established around station a complex of land uses and densities to fit their position in the urban area. Development with a focus on public transportation will reduce costs and other consequences of wasted trips within the city by increasing travel choices, thus reducing the per capital availability of land in urban landscapes.

Public transport oriented development can increase the efficiency of public transport services, resulting in improved and more useful performance. The creation of communities and urban centers in centralized social and physical locations are more favorable, and will improve quality of life within the community.

The proposed method increases ease of access and the number of available travel options through land concentration and composition, leading to the development of non-motorized transport.

Public transport oriented development can increase the practicality of walking and cycling to accomplish daily tasks and reduce the distance it is necessary to travel by mechanized methods, reducing private vehicle use and urban traffic.

The public transport system further develops social justice in cities through the equitable distribution of public transport facilities and by providing easy access to a variety of user requirements. The ability to walk to attractive areas including shops, restaurants, coffee shops is beneficial, and neighborhood streets should be designed to maintain safety and security. High quality public transport as well as the development of high-capacity and high-density urban centers facilitates access and the effective accomplishment of daily trip goals.

Results confirmed those reported by Canpzd, Hedayati, Rezazadeh, IPCC and Savy [31-35]. Based on these results, the organization of public transport-oriented development systems based on the physical, social and economic suggestions in Table 4 are recommended.

TABLE 4 STRATEGIES AND RECOMMENDATIONS (SOURCE: AUTHORS)

| First objective: enhance power of the local economy. | |
|--|--|
| Implementation mechanism | Strategy |
| 1. Establish commercial centers in easily accessed areas parts that can provide services to other districts. | Promote economic power of citizens and municipalities with respect to discussed patterns in district sustainable development theory. |
| 2. Prevent increasing revenue in the municipality by selling building density. | |
| 3. Use the taxes from commercial and cultural centers to improve and modernize and create new jobs. | |
| 4. Create jobs through the development of district tourism industry. | |
| Second objective: strengthen neighborhood identity | |
| Implementation mechanism | Strategy |
| 1. Strengthen the tourism identity through fit landscape design. | Identify and increase neighborhood power for district, regional and urban applications. |
| 2. Increase legibility of neighborhoods through urban signs. | |
| 3. Strengthen public education and raise awareness among citizens. | |
| 4. Hold festivals and music performances in community centers. | |
| 5. Design the neighborhood center and public outdoor areas using local building materials. | |
| 6. Create communal spaces and evocative centers at the district level. | |

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