"Review Paper"

Overview of the Literature on the Transit-Oriented Development Policy to Investigate a Practical Solution for Traffic Congestion in Iran Cities

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Received: 08.10.2019 Accepted: 24.01.2020

Abstract

Expanding public transportation is not enough to solve the urban sprawl problem resulted from an auto-orientation perspective. So urban planning experts paid attention to integrated and coordinated planning of urban development with public transportation, which reached to sustainable urban development. The purpose of this study is to review the researches in transit-oriented development (TOD) and present practical solutions to implement TOD in Iran cities. In this paper, urban sprawl has been introduced, and three significant solutions (Smart Growth, New Urbanism, and Transit-Oriented Development) have been checked to prevent it. Then the researches in TOD allocation by various methods and modifying land uses around transit stations have been investigated. Moreover, the effects of TOD on city structure and the decisions of individuals in choosing a place of residence have been examined. Also, methods for assessment of TOD impacts and the prosperous cities, which implement the TOD, have been introduced, and finally, the practical solutions for implementing TOD in Iran cities have been presented. Based on a review of the previous studies incorporated in this paper, the practice and integration of TOD through land use and transportation showed that TOD could be the alternative solution in addressing the problems of developing the urban area.

Keywords: Transit-oriented development, new urbanism, smart growth, traffic congestion, iran cities

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1. Introduction

Up to now, various papers, theories, and investigations about land use and transportation interactions have been presented by researchers. Some have sought to present a model for assessment of interactions and to find a model for a specific location. Others have presented a flexible, localized, and executable approach by considering the main essence of these changes. Among all these theories, new urbanism and smart growth have been focused on executable solutions in simultaneous planning of transportation and land use, and new theories and approaches like TOD has been obtained in a particular place to solve this problem. The results of studies in different parts of the world have shown the impressibility and continuity of physical-spatial urban changes (consist of land use changing, land prices, building density) rather than urban network transportation changes (roads and communication nodes, volume and action scale and the quality of transportation services). Therefore, investigate these changes by using TOD can help us to identify continuity model changes and to find a way for controlling undesirable changes and to achieve an optimal model because of making constructive changes in the urban context in the future [Noripayam and Norian, 2010]. Figure 1 shows the structure of the study.

2. Urban Sprawl and Effects

After World War II, decentralization and the increasing use of cars were two of the most alarming phenomena of interest to urban planners in the United States. Increased investments and subsidies for car users, in return to a low budget for public transportation, make cars a top priority for travelers. The accessibility to lower-cost housing in the suburbs and the high ability of the city for driving cars created a wave of migration from the suburbs to the city; this phenomenon was named urban sprawl in the urban planning literature [Soltani and Kono 2006].

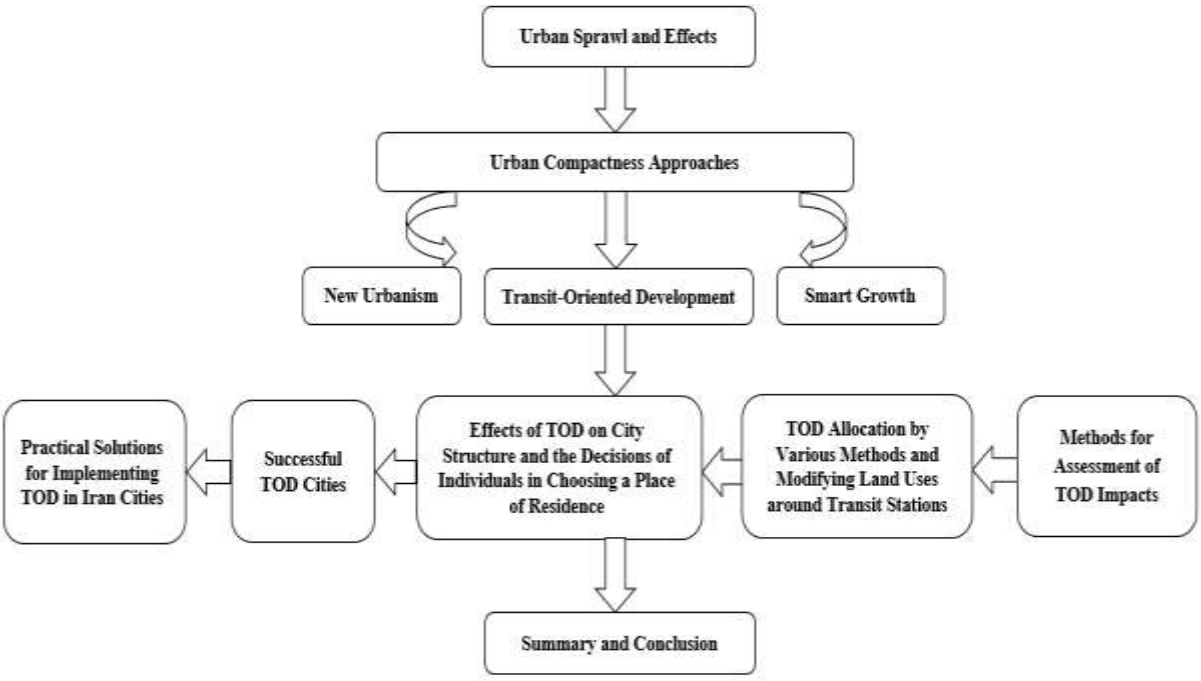

Figure 1. Structure for the Study

Urban Sprawl has a range of negative consequences, including social, economic, environmental, and traffic problems [Gardner 2013].

2.1 Social Consequences of Sprawl

Those living in sprawling suburbs have longer commute times and distances to travel for work, to shop, or for recreation. As a result of sprawl, cars, attached garages, and consumerism, the social experience of the Walking-Horsecar Era has been stripped away from the city and replaced by solitary, isolating commutes. The car and garage have been agents of social isolation, while consumerism has created a suburban landscape robbed of identity. The suburbs are over run with chain stores, restaurants, gas stations, and hotels repeated over and over in nearly every city. These suburban destinations are designed for vehicular access, and therefore promote a more sedentary and unhealthy lifestyle.

2.2 Economic Consequences of Sprawl

By attempting to escape the city and return to nature, a growing population has relentlessly consumed the land surrounding the dense, historic core of American cities. The expansion was primarily funded by the public, as the federal government used taxes to expand highways, utilities, and other infrastructure out into the countryside. Further, those lured out into sprawling areas by the perception of less expensive housing soon discovered that operating costs for personal transportation become a large percentage of their income.

2.3 Environmental Consequences of Sprawl

Expansion of development into undeveloped watersheds increases impervious surfaces, which introduces additional storm-water runoff volume and degrades water resource quality. Additionally, this expansion is rapidly consuming agricultural lands and robbing landscapes of their natural resources and beauty. Further, the low-density nature of sprawl almost always requires it to be accessed via automobile. Therefore, the number of cars on the road has increased, which results in a rise in air pollution from exhaust [Gardner 2013].

2.4 Traffic Consequences of Sprawl

One of the first and most extensive studies on the impacts and consequences of urban traffic congestion is a study by Newman and Kenworthy on the relationship between density and fuel consumption in different cities around the world. The results of studies on 83 cities about the impact of sprawl on travel behavior show that in more sprawl cities, travel variables such as length of trip, car ownership, and accident rates are increased and instead of walking rates, and public transport utility are decreased [Newman, P. and Kenworthy 1999].

3. Urban Forms and Compactness Approaches

The TOD has a role in reshaping urban forms. It is expected to have changed in land-use patterns to encourage the development of higher-density mixed-use urban activity centres around the mass transport stations and discourage lower-density decentralized sprawl [Knowles, Ferbrache, 2019]. The compaction of urban spaces in the urban planning literature has a background that its approaches have been outlined in Figure 2 and three important approaches are discussed [Alipour, Soltani, and Hosseinpour, 2017].

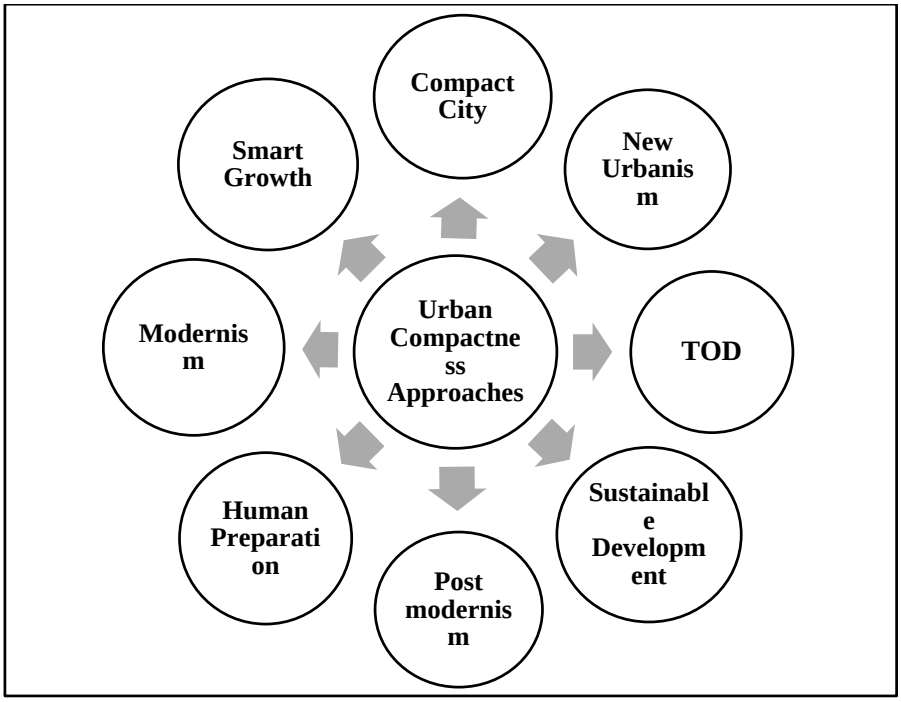

Figure 2. Urban Compactness Approaches [Alipour, Soltani, and Hosseinpour, 2017]

3.1 Smart Growth Movement

Smart growth can be defined as a set of development and land use principles that seek to enhance the quality of urban life, preserve the environment, and provide economic savings over time. The smart growth approach adapting to other approaches such as Transit-Oriented Development, mixed-use, and compact development focuses on development around public transport stations. In this regard, it is suggested that public participation is essential during the TOD. Their other proposals also emphasize on parking management, retail development, and mixed-land use [J. Renne 2008]. Smart growth advocators want to optimize existing infrastructure instead of creating new infrastructures. Instead of developing agricultural lands and forests, they are trying to focus on development and ultimately try to reduce traffic and focus on affordable housing and sustainability [Brown et al., 2009]. Smart growth is a theory of urban planning and transportation planning that focuses on the growth of compact pedestrian-oriented centers to prevent urban sprawl. This view is based on the assumption that the proper distribution of land uses and compact urban form help us to think about active transport. The Smart Growth Strategy outlines the following principles that different societies can adapt to some of these principles, depending on their specific geographical and socio-economic conditions [EPA, 2001].

EPA's ten guidelines for smart growth are as follows:

1. Creating Mixed land Uses 2. Emphasize the benefits of compact building design 3. Providing different housing selection options 4. Create neighborhoods with pedestrian access 5. Create neighborhoods with a strong sense of place 6. Protecting open spaces, farmland, beautiful nature, and environmentally sensitive areas 7. Strengthen development in existing communities 8. Providing a variety of transportation options 9. Decisions for possible development 10. Encouraging communities and stakeholders to participate in development.

3.2 New Urbanism Movement

New Urbanism is a planning approach based on the principles of how cities had been developed

for the last several centuries: walkable blocks and streets, housing and shopping nearby, and accessible public spaces. In other words, New Urbanism concentrates on human-scaled urban design [CNU, 2008].

In this regard, the New-Urbanism congress first started with a collection of designers, theorists, and politicians, and overtime included academic scholars, economists, planners, transportation engineers, sociologists, and environmentalists. The congress developed its charter in 1996, which provides a positive outlook for local communities. Their values and the core principles of their work are explained in the Charter of the New Urbanism [CNU,2008]. The charter of the New Urbanism Society begins with this statement: "The Congress for the New Urbanism views disinvestment in central cities, the spread of placeless sprawl, increasing separation by race and income, environmental deterioration, loss of agricultural lands and wilderness, and the erosion of society's built heritage as one interrelated community-building challenge." Basic principles of New Urbanism are as follows:

1. Walkability
2. Connectivity Factor
3. Structure of the Neighborhood
4. Diversity
5. Environment-Friendly Urban development
6. Density of population
7. Mixed Housing & Aesthetic Urban Planning
8. The Objective to Improve Quality of Life

3.3 Transit-Oriented Development

The most comprehensive definition of transit-oriented development provided by Peter Calthorpe, a leader in the New Urbanism movement. He describes TOD as "a mixed-use community within an average 2000-foot walking distance of a transit stop and core commercial area. TOD's mix residential, retail, office, open space, and public uses in a walkable environment, making it accessible for citizens and employees to travel by transit, bicycle, foot, or car". Urban TODs are located directly on the trunk line transit network: at light rail, heavy rail, or bus stops. They should be developed with high economic intensities, job clusters, and high residential densities [Calthorpe and Poticha 1993]. The proposed diagram of Calthorpe is shown in figure 3. The principles of transit-oriented development are as follows: 1. Planning for the adjacent area of the station and changing its role from one node to one location 2. Establishing neighborhoods and compact residential blocks along with favorable pedestrian routes 3. The combination of land use (mix land use) 4. Increasing the optimal height and building density (medium to high) 5. Enhancing the quality and accessibility of transit and parking management 6. Promoting non-motorized transport modes such as cycling and walking 7. Excellent design and development of a network of green and public spaces 8. Providing varied options for housing in terms of form, combination, and price [Alizadeh and Abdi, 2013]. A typical land use arrangement around a transit station can be seen in Fig. 4. Compact mix-use structures are clustered around the metro stations. These have a high density and diversity. Smaller structures are placed away from the station [Sahu, 2018]. As a result of following the above principles, the most important advantages of this approach, all aimed at strengthening sustainable urban neighborhoods, can be reduce the ownership of private cars and their fuel consumption, reduce the traffic congestion and its pollution, make affordable housing, revival of urban neighborhoods, economic development, and increasing land value [Alizadeh and Abdi, 2013].

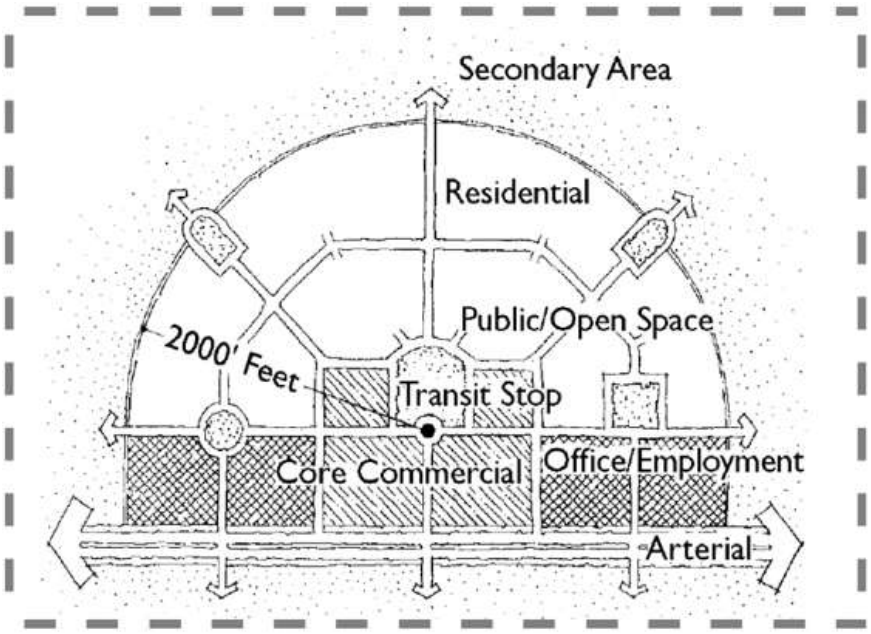

Figure 3. Proposed Diagram for TOD by Peter Calthorpe [Calthorpe and Poticha, 1993]

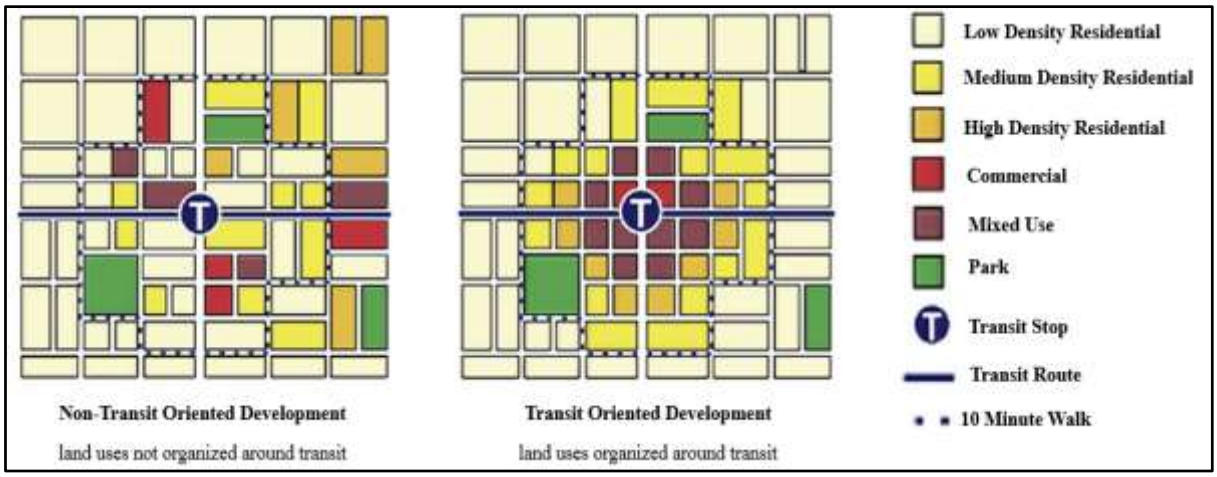

Figure 4. Modify land uses around transit stop based on TOD principles [Sahu, 2018]

Besides, new developments based on TOD are sometimes at odds with historic preservation, but with mutual planning efforts in regard of transportation and land-use planning, historic preservation would increase the desirability of TODs and this opportunity can aid in TOD implementation [Renne, J. L., & Listokin, D. 2019].

4. Methods for Assessment of TOD Impacts

Methods for measuring TOD impacts are analytical and simulation-based [Taeihagh, A., Banares-Alcantara, R., & Millican 2009; Macharis, C., & Bernardini 2015]. Analytical methods generally involve three critical analysis: cost-benefit analysis, cost-effectiveness analysis, and multi-criteria decision analysis techniques [Browne, D., &

Ryan, 2011]. Analytical methods also contain the forecast of land-use changes in the context of access to transit stops, residential property value changes, residential/commercial permitting rates around stations, and reducing neighborhood environmental contamination [Geurs, K. T., & van Wee 2004, Hatzopoulou, M., & Miller 2009, Guthrie, A., & Fan 2013]. Analytical methods can be divided into aggregate and disaggregate models. Aggregate models investigate the impact of transport policy at the level of the whole study region. Disaggregate models tend to examine policies' influences on individuals. Surveys are crucial for disaggregate models [Eboli, L., & Mazzulla, 2011; Idris, A. O., Nurul Habib, K. M., & Shalaby, 2015].

Simulation models are generally created by a series of input/output data. The input data include the policy scenario and present land utilization data. The output data often include indicators like housing prices, transport mode split, accessibility, and walkability of the study area. Some of the most potent simulation models include computational modeling approach, Cellular Automata models, multi-agent models, system dynamics models, and discrete event simulations [Ku, 2016]. New and emerging analysis techniques such as GIS tools, visualization technology, and remote sensing are used for the evaluation of TOD [Heeres, N., Tillema, T., & Arts 2012], [Mishra et al., 2014]. [Nelson and Niles, 1999] and [Jeihani et al., 2013] developed a tool and combined with the urban simulation techniques to predict the TOD project success. These tools help us to use the simulation technique to recognize the future impacts of TOD.

5. TOD Allocation by Various Methods and Modifying Land Uses around Transit Stations

In a study by Sung and oh, focusing on the implementation of transit-oriented development factors in Seoul, South Korea, emphasizes that transit-oriented development planning factors can have a positive effect on the formation of a transit-oriented development city. They recommend instead of focusing on increasing the development density, focus on the mixed-land use index, strengthening public transport services, rebuilding street networks, and designing urban areas to improve walkability around stations [Sung and Oh, 2011].

Alizadeh et al., based on the results of Strengths, Weaknesses, Opportunities, and Threats (SWOT) analysis, proposed several strategies regarding the objectives of the research including increasing spatial and functional sustainability, increasing accessibility, providing sustainable transport options along with easy pedestrian movement, and reducing environmental challenges. The results show that for implementing TOD as a solution to the auto-oriented urban pattern, it needs to capture a broad market view from both sides of private and public sectors [Alizadeh et al., 2013].

Ma et al., present a multi-objective planning model that includes five goals and two decision variables, to plan land use around a metro station in Beijing. Considering the unique characteristics of urban development (e.g., high density and diversity), five objectives are taken to account in their model, including rail transit ridership, compactness, accessibility, conflict degree, and environmental effects. An improved immune-genetic based algorithm is created to obtain optimal solutions under alternative land use schemes. The model can output alternative land use plan schemes with the layout and the land use density around the studied subway station [Ma et al., 2018].

In a study by Wey et al., TOD's standard selection criteria have been formulated to meet the principle of sustainable transport. The fuzzy Delphi technique was used to select TOD evaluation criteria and the fuzzy analytic network process (FANP) was employed to determine the weights of relevant planning criteria. The results show that all 9 TOD

evaluation criteria for sustainable transport supported by an expert group in the first phase of the study were critical to the TOD assessment. In the second step, according to the weighted evaluation criteria, high density was the most important criterion, while the least critical criterion was equality in residence accessibility. Finally, by using Geographic Information System (GIS), the performance of each station on the Ankeng line of the New Taipei MRT system was evaluated based on TOD evaluation criteria. Combining the evaluation with the Fuzzy Analytical Network Process (FANP) weighted values showed that the Xinhe Elementary School MRT station is the optimal station for TOD [Wey, Zhang, and Chang, 2016].

In Sahu's research, a method for modifying land uses in a transit-oriented development scenario is explored. The purpose of this study is to build a methodology for modifying land uses around selected stations for TOD using a mathematical model. Global TOD parameters (density, diversity, and distance to transit) were studied. Attributes for TOD parameters were extracted through expert opinions. Then a mathematical model with four sub-objectives is developed to investigate land-use modification at two selected stations of Naya Raipur for TOD implementation. First was to maximize TOD characteristics (Housing density, Employment density, Mix use structures). The second was to shape the skyline (minimize deviation from ideal TOD skyline). The third was to minimize the degree of land-use change, and the fourth was to increase the overall compactness of the plan. By coding this mathematical model through a Genetic Algorithm (GA), the best-generated plan to change the land uses around selected stations is introduced [Sahu, 2018].

Ming Wey's study first classifies the principles of smart growth based on literature review. A team of experts consisting of six experts first assigns the main weights to each criterion. Then, six sets of scores are averaged for selecting the possible location of each station. A combined Fuzzy Analytic Hierarchy Process (FAHP) and Data Envelopment Analysis (DEA) model with an assurance region approach are applied to select the most suitable station from a given set of possible station sites. Two stations have been selected and proposed for the public sector [Wey, 2015].

6. Effects of TOD on City Structure and the Decisions of Individuals in Choosing a Place of Residence

Lo et al. found that residents living in transit-oriented development areas used public transportation more than other residents of the city in different neighborhoods. They also emphasize that the proper combination of land-use, characteristics of the transportation stations, demographic, economic and social aspects and the competition between modes of transport is effective in changing the rate of public passenger transportation [Loo, Chen, and Chan, 2010].

Bailey et al., by using the regression model, concluded that the average daily mileage of families within a 1200-meter range of high-quality public transportation services is 11.3 miles per car, about 26 percent, regardless of land use density and personal vehicle ownership. They also state that the residents of the transit-oriented development districts tend to have less property of vehicles and driving, and are more dependent on hiking and using public transportation than residents of other neighborhoods [Bailey, Grossardt, and Pride-Wells, 2007].

In Ratner and Goetz's research, the reshaping of land use and urban form in Denver has been explored through transit-oriented development. Denver, Colorado, is one of the cities that expands its rail transportation system and encourages high-density mixed-use development at stations. This study examines TOD data for 0.5 miles around the railway stations. Early evidence suggests that transit-oriented development in Denver is significant,

which includes about 18,000 residential units, 5.3 million square feet of retail space, 5.4 million square feet of office space, and 6.2 million square feet of medical space within one-half mile of existing or planned transit stations from 1997 to 2010. The emphasis on transit-oriented development is helping to increase the average density of the Denver area [Ratner and Goetz, 2013].

Duncan's research responds to this question that would the replacement of park-and-ride (P&R) facilities with transit-oriented development reduce vehicle kilometers traveled (VKT) in an auto-oriented US region? At four of the seven stations examined in this study, replacing a P&R facility with a moderately dense housing (100 units per hectare) is predicted to result in a net VKT reduction. This research indicates that replacing P&R facilities with TOD would result in a net VKT reduction at some, but not all, LYNX stations that currently have P&R facilities. Surface P&R facilities that are either underutilized or close to the Central Business District (CBD) make particularly good candidates for replacement [Duncan, 2017].

In a study by Olaru et al., TOD effects on choosing a place of residence in two areas of Western Australia are checked. Analyzing the opinions of interviewees on access to transportation and urban facilities support the hypothesis that environmental characteristics play an important role in relocation decisions. A series of discrete choice models also show that households value housing attributes, the quality of the surrounding environment, and proximity to transport and facilities such as shopping and schools, parks, and friendly places where to walk or cycle. Preferences for bigger houses and proximity to “everything” occur among higher-income and more prominent families with school-aged children. The choice for open, greener spaces is consistent with the greater focus on reducing obesity and enhancing the quality of life. The best models are Latent Class Models (LCM) with social variables and Hybrid Choice Models (HCM) with latent variables; they demonstrate that land use predispositions affect location decisions. According to the results of this research, it can be concluded that households with the same demographic characteristics choose different housing options [Olaru, Smith, and Taplin, 2011].

Nasri and Zhang's research focuses on TOD analysis in urban areas of Washington DC, and Baltimore. The present study tries to find out how travel behavior is different for TOD residents in the two urban districts of Washington DC and Baltimore. It is explicitly done by examining the changes in vehicle miles traveled (VMT) to analyze the impact of the TOD on encouraging driving less and starting to use public transportation, hiking, cycling and other sustainable modes of transportation. This paper, by analyzing the VMT of Washington DC residents and Baltimore, indicates that people living in TOD areas tend to drive less, reducing their VMT by around 38% in Washington, D.C. and 21% in Baltimore, compared to the residents of the non-TOD areas even with similar land-use patterns [Nasri and Zhang, 2014].

Zhao and Shen's research is about the impacts of rail transit on future urban land use development: A case study in Wuhan, China. This research considers a multinomial logit model (MNL) and the land-use allocation model to quantify the effects of Urban Rail Transit (URT) on urban land-use change. Land use data from 2000 and 2010 were used to analyze land-use changes at three railway stations. The results show that the model is useful in quantifying the effects of URT and can reflect them in simulating land-use change. Finally, future land use plans in 2020 are produced [Zhao and Shen, 2018].

Mu and Jong's research focuses on establishing the conditions for effective transit-oriented development in China: the case of Dalian. Dalian has a good tradition in using public transport, which officially embraced the TOD planning method. Results are drawn as to where

Dalian's strengths and weaknesses invention and what actions the Dalian government has taken about each of these conditions. In conclusion, to transfer the TOD lessons of Dalian to other Chinese cities, they achieve that to make TOD work in China, cities should at least encounter all critical conditions such as pedestrian-friendly urban design, good governance, and high-quality transit services [Mu and de Jong, 2012].

7. Successful TOD Cities

Perth is the capital of Western Australia state with a population of one million nine hundred thousand, the largest city in Western Australia, and Australia's fourth-largest city. Implementing TOD in this city is set up by the Metropolitan Redevelopment Institute. The goal of this institution is to rebuild the city of Perth by planning and promoting the development of deserted industrial sites and other less developed areas to create valuable places for people who want to be part of it. The main objective of the project is to achieve a proper design and development in the city of Perth, through the creation of valuable public environments, high-quality buildings, the creation of links between people and places, a successful combination of applications and activities. The primary goal of this project, as well as other urban regeneration projects, is to progress to a sustainable future for the people of Perth. Perth's redevelopment project consists of several separate projects that have been scattered across the city of Perth and constitute the entire study area. The strategies of this project include aspects of land use, development management, and social and historical heritage. The most important principles used in the preparation of this project include creating spaces for people, high density, high-quality design, variety and mixing, connectivity, and environmental integrity, based on sustainable urban renewal principles [J. L. Renne, 2005].

Curitiba is the capital of the state of Parana in the south of Brazil, near the city of Sao Paulo. The city, with a population of one million nine hundred thousand, is the eighth largest city in Brazil and the largest city in southern Brazil. The lines of the bus rapid transit, connecting the transportation centers by equipping the stations every 500 meters. In the 1970s, only seven percent of the traffic was transported by public transport. It reached 75 percent in 2006, equivalent to 23,000 passengers per hour. In general, the share of travel for each mode equals 23% of personal vehicles, 5% motorcycles, 5% of bicycles, 21% of pedestrians and 45% of public transport (bus). The statistics show that 85% of the population of Curitiba is using rapid buses. The five arterial axes extend from the city center to the outside of the city and act as the axis of development and paths of growth. These axes distribute traffic in the center of the city by connecting two circular rings. Two blocks with high buildings and high density cover these main axes. Departing from public transportation routes, the amount of building density decreases. Density distribution in the city of Curitiba is carried out in four different districts. As the distance from the system's lines increases, the density decreases. With this zoning approach, urban planners have been able to provide easy access to the public transportation system [Suzuki, Cervero, and Iuchi, 2013]. After World War II, urban planners in Copenhagen in 1947 formulated the Urban Development Plan, which represents the transit-oriented development planning. The program was called the Finger plan, which became famous throughout the world. Urban development in this program was carried out along the five axes of metro rail transport, which included five fingers connecting these areas to the city's central commercial district (Figure 5). The approach as a method integrating the metro lines along the axes with services, businesses, and residential units around the station in the suburbs, while simultaneously emphasizes on public

transportation with the development of pedestrians and bicycles.

Figure 5. Copenhagen's 1947 Finger Plan [Knowles, 2012]

The main goals of the expansion of this approach in Copenhagen are improving communication and interaction with the central core of the city, controlling the traffic of private vehicles, the economic growth of the town and the region, reducing the

pressure on the central business district of the town and also growing and maintaining a position in international competitions [Knowles, 2012].

Calgary is the largest city in the state of Alberta, located in the south of the state, and according to the 2006 census, the city has a population of 193988 people. Calgary has a community with a successful transit-oriented development located within the bridge Avenue. This sector has apartments, shops, service units, and various parks. The city of Calgary has developed a new transit-oriented development policy for its neighboring communities. The Calgary City Council has allocated funds for the construction of three subway stations in the neighborhood and suburban areas to speed up the development of neighborhoods near light rail stations. In June 2008, the Calgary City Council approved for the first time a wide-area zoning program in an urban area [Calgary city, 2004].

8. Practical Solutions for Implementing TOD in Iran Cities

TOD is an urban reform package that makes the subway or any city's public transport system more efficient. The TOD and its reforms omit the cars in the streets and deliver it to pedestrians and cyclists; in other words, it makes the city human-oriented. With its free reforms, TOD brings vitality and vibrancy back to neighborhoods, strengthens the local community, and boosts the urban economy [Tehran City Council, 2017].

Researchers agree that inner-city TOD perhaps has more significant potential for success than suburban or greenfield TOD because of naturally higher concentrations of residences, jobs, and amenities. However, there are

significant challenges for developing the built-up areas, and these challenges perhaps explain the slow implementation of TOD in some depressed inner-city areas. Researchers also agree that TOD is least likely to succeed in places with few amenities to claim as a locational advantage, which further strengthens arguments for urban locations (with higher densities and mixed land use) over suburban locations [Daniel Baldwin Hess, 2004]. Iran's cities that have the capability for implementing TOD are mostly in the category of inner-city TOD in a built-up area. Eight crucial modifications that have been referred by TOD standard [ITDP, 2017] are needed to implement TOD in built-up areas like Iran cities.

1. Transit (Locate development near high-quality public transport)
2. Densify (Optimize density and transit capacity)
3. Mix (Plan for mixed-use)
4. Connect (Create dense networks of streets and paths)
5. Compact (Create areas with short commutes)
6. Shift (Increase mobility by regulating parking and road use)
7. Walk (Develop neighborhoods that promote walking)
8. Cycle (Prioritize non-motorized transport networks)

8.1 Transit

Walkable access to rapid transit, defined as rail transit or bus rapid transit (BRT), is essential to the TOD concept. The maximum walking distance to the nearest transit station is defined as 1000 meters. The city is zoned by creating circles of 800 to 1000 meters radius around the subway or BRT stations that are called TOD zones. A radius of 200 to 300 meters in TOD zones is considered, which is called the core of the zone. It is better to consider less radius in zones for small cities.

8.2 Density

High densities should only be at the core of the zone. Any high-density buildings that exist in other parts of the zone are not important. After that, it shouldn't be built high-density commercial, office, and residential buildings outside the core of the station zone. After ten years, the private sector and investors will condense around the station. Density justification around stations should be proportionate to the capacity of the station. This will have proper revenues from the tolls of zone central density.

8.3 Mix

All densities in the core of the zone should be defined as mixed land use. This will prevent the stations from changing to office, commercial, and residential pole. Mix zoning at the core of the zone will be enough to form different businesses, and major commodity and service requirements of TOD zone residents will be fulfilled. Part of the daily and nightly vitality of different neighborhoods and areas of the city depends on this simple decision. Of course, it can be done for other parts of the zone. In human-oriented urban design, the separation of administrative, commercial, and residential are rejected.

Any public and non-specialist service must be provided in each zone or eventually one of its adjacent zones and accessible to pedestrians or bicyclists. Mix density will increase the population that lives alongside commercial land use of the zone core. This will increase local vitality and will reduce the car requirement by integrating markets and people. The local economy will prosper. At the core of the zone, social housing will also be formed. The mix of market and people and the mix of low-income and high-income citizens are essential for TOD.

8.4 Connect

The block size in each TOD zone is very vital. The block size is the distance between the intersections. If the size of the blocks will be more than 150 meters, you should consider creating a low-pass road just for pedestrians and bicycles. Long alleys are visually boring and not attractive to pedestrians. Pedestrians and bicyclists' access networks should be

developed. This modification component is important for TOD implementation in a city or at least in a part of more important zones even though it has appropriation cost. This is necessary for active walk mode. If a detailed city plan is modified these low width roads that are beneficial will emerge gradually. For new and underdeveloped sections of the city, we must think of blocks below 150 meters. In areas that do not have proper connecting, modifying the dead-end defect that is the cause of the impermeability and incentive for parking cars should be considered in a new detailed plan.

8.5 Compact

With shorter distances, compact cities require less time and energy to travel from one activity to another, need less extensive and costly infrastructure, and preserve rural land from development by prioritizing the densification and redevelopment of previously developed land. Distance between TOD zones increases the cost of public transportation construction. Garrisons, factories, and useless lands keep TOD zones apart. In addition to the cost of public transportation, there will be a neighborhood-break, too. The distance to the neighbor zone service center will be out of walking scope. For example, if a pharmacy does not exist in a zone, nobody usually uses the subway to buy medicine from a neighbor zone. If the neighbor zone will be so far and will not be accessible by pedestrians or bicycles, people will use their private cars. For empty spaces at the core of the zone, we should consider mix land uses or accessible public spaces.

8.6 Shift

The land occupied by motor vehicles should be minimized, and zone roads should be suitable for all four modes of transportation. The shift is essential to activate pedestrian and bicycle modes. For shift, zone highways should be redesign for three public, private cars, and bicycle modes; zone arterial roads should be redesign for four public, walk, bicycle, and private car modes and collectors and access roads should be redesign for three walk, bicycle, and private car modes. In other words, the roads should be changed to "complete streets." Complete streets fit pedestrians, cyclists, and cars together and create a multi-modal transportation network. In other words, complete streets are for everyone. They are designed and implemented for all users to secure access empowerment. Restrictions and bans should be imposed as far as possible about the car parks. Cost restrictions or entry prohibition like marginal park complications or congestion charges are the examples that we can refer to them. As an example Figures 6 and 7 show the before and after of the proposed plan of Motahari complete street in Tehran.

Figure 6. Tehran Motahari Street before TOD Reforms [Tehran City Council, 2017]

Figure7. Tehran Motahari Street after TOD Reforms (Complete Street) – Proposed [Tehran City Council, 2017]

8.7 Walk Mode

Walk mode is the mother of transportation modes in TOD reforms. Activating walking mode will lead to the human-oriented, vitality, succulence, and urban community empowerment, the health of citizens, the prosperity of urban businesses, and ultimately the growth of urban viability and sustainability. Car problems are solved by asphalt and traffic signals, and cars have no other basic needs, but pedestrians have many needs to walk. Sidewalks in TOD should have the following features: 1.Safety 2.Wide passage 3.proper pavement 4.Cool shade 5.proper lighting 6.vitality 7.Beauty 8.Green areas and architectural creativity 9.Comfortable and accessible furniture.

8.8 Cycle

Cycling is the second-most healthful, affordable, and inclusive mode of urban mobility. In inner zone trips, which walk mode is important if this mode will be active, those people that speed is their trip requirements do not need to use the car. The bicycle mode also in outer zone trips is a mode to achieve the destination and transit station. The key factors in promoting cycling are the preparation of safe street conditions for cycling and the availability of secure cycle parking and storage at all trip origins and destinations. It is not necessary to design a bicycle network for the city in the TOD approach. Each zone with its bicycle roads and network that its design details are in TOD instructions is joint to bicycle roads of the neighbor zone, and this will create the whole city bicycle network. All width of the road will be modified in TOD, and the bicycle roads will be designed after allocating the walk share. There will be a rework and disinvestment if these integration and transposition do not accomplish [Tehran City Council, 2017].

Finally, it seems that implementing a successful TOD does not impose any cost on city management. The cost of rehabilitation the transportation system will be provided by mixed density, although it is not a sustainable income, but a disposable source for improving the quality of public transportation. The shift will also supply sustainable income. Price limitations or entry prohibition like marginal park tolls or congestion charging are samples that we can indicate. Activating the pedestrian mode presents a new income that depends on roads and its land-use classification. The implementation of TOD does not cost much, but it generates revenue for municipalities and states. The expensive section of TOD implementation is related to subway and BRT development, but if TOD does not implement, these costs still exist. In fact, these costs do not relate to TOD. Another part of implementing detailed TOD features, especially at the passage level, is a low-scale initial investment that the rest can be developed from TOD monetization.

9. Summary and Conclusion

As described, transit-oriented development at any scale offers appropriate opportunities for dense and mix development and can be considered as an effective way to achieve an integrated model of land use patterns and transport planning around the stations and determine the sustainable way of relocation in urban areas. However, transit-oriented development planning will lead to beneficiaries' participation and the continuous presence of residents in the planning and decision-making process. The successful results of TOD implementation in other countries that four of them have been reviewed in this paper cause to find a pattern for applying it in Iran cities. This study investigated eight significant changes for the successful implementation of TOD in these cities. Then the methods for assessment of TOD impacts and the researches in TOD allocation by various methods and modifying land uses around transit stations were investigated. In the next section, the effects of TOD on city structure and the decisions of individuals in choosing a place of residence were examined. Reviews show that in developing countries where the TOD has not yet been implemented, the main concern is to find the optimal location to implement the TOD and to reform policies in the city's comprehensive plans for the implementation of the TOD. Iran cities are also part of this category. However, in the developed countries where TOD is implemented, the main concern is finding the effects of TOD implementation, and the main question in most researches is to what extent TOD has been successful in solving urban issues such as urban congestion, reduce travel time, and car dependency? The implementation of TOD can reduce congestion by facilitating the population preference of public transport in comparison to private modes of transportation and improved environmental quality. However, of course, it

takes a strong commitment and consistency of the stakeholders to be involved in the implementation of TOD persistently.

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