# THE EFFECTS OF TRANSIT CORRIDOR DEVELOPMENTS ON THE HEALTHCARE ACCESS OF MEDICALLY FRAGILE VULNERABLE POPULATIONS

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## ABSTRACT

Transportation has been identified as a major barrier to healthcare access, particularly, within vulnerable population groups. The level of healthcare access that most population segments have in traditional transit systems may be increased with new initiatives that involve complex and large investments in transit oriented developments (TOD) projects. However, the increasing attractiveness of neighborhoods affected by TOD initiatives may result in the gentrification of vulnerable population segments. These vulnerable segments are likely to be relocated into less attractive neighborhoods characterized by inadequate transit systems. This relocation increases the probabilities of reducing healthcare access for these underserved groups leading to an increase in health disparities. The present discussion calls for research to explore relevant factors that affects these dynamics. A framework that enables the identification of individual factors that affect gentrification processes under TOD initiatives as well as quantifying the effects from these processes is suggested in this paper. A system dynamics framework that allows the understanding of the dynamics associated with this system is suggested in this paper. Critical areas for empirical research are highlighted. These are prerequisites for the effective deployment of initiatives that ensure the mitigation of possible negative impacts on vulnerable populations.

## 1. INTRODUCTION

Transportation has been cited one of the most critical barrier to access to healthcare (Institute of Medicine 1993). A large number of studies indicate the negative impacts of transportation barrier towards access to healthcare, predominantly, for vulnerable population. Rittner and Kirk (1995) report that a majority of low income old people in poor health condition depended on public transit as their only means of accessing healthcare services. Okoro et al.(2005) report 'lack of transportation' and a possible dependence on public transportation as one of critical barriers to healthcare, especially for women, in a study of overcoming the barriers to preventive care among older population. Similar results are reported by Fitzpatrick et al.(2004). Flores et al.(1998) found that transportation problem was cited by 21 % of the parents as the reason for lack of access to healthcare when studying the barriers to healthcare access among Latino children. Ahmed et al. (2001) report comparable results from studying barriers for non-elderly, poor Americans segments in urban settings. In a study conducted in a community health center settings, Shook (2005) reports that 32 % of the patients reported a transportation barrier within the last year, with most problems related to transit. Consistently, this author finds that this barrier affects the vulnerable populations more severely than the rest. From the discussion above it is evident that transportation remains to be a major barrier to healthcare and that transit is a possibly inefficient but the only (and hence important) means of accessing healthcare especially for the most vulnerable populations.

### 1.1. Background

The idea of promoting livability through development centered on transit corridors has generated a significant attention from the public opinion in recent times. The concept of livability is centered around the degree of equivalence between the needs of individuals and the provisions within the society/environment to satisfy those needs (Veenhoven and Ouweneel 1995). Livability is concerned with the need of an individual to live in a socially amenable environment that promotes individual as well as collective well-being (Newman and Kenworthy 1999). Public transportation plays a unique and important role in promoting livability. Transportation hubs (stations) become points at which

people meet and interact with each other; stations become centers of commerce and social events and recreation while providing better mobility to people by connecting neighborhoods (Transportation Research Board 1997). Most important elements of TOD include higher density and mixed land use, and ease of access to high quality public transportation in which car rides are replaced by walking and biking and creating a sense of identity within the community (Cervero, Ferrell et al. 2002). During the past decade a large number of major urban centers in the US are planning or implementing some class of mass transit system using TOD as a base (Belzer and Autler 2002). This idea is gaining momentum among local and state governments as well as federal transportation agencies.

A critical consideration that emerges from the discussion above is the effect of transit oriented initiatives on an already weak level of access to healthcare that elderly and medically fragile vulnerable populations have. Particularly, the rising cost of housing in areas that have easy access to public transportation under TOD initiatives are likely to make those housing options unaffordable to these vulnerable segments. The gentrification of low-income neighborhoods due to TOD may cause a reduced access to public transportation for vulnerable populations. This further impedes their access to healthcare.

Gentrification effects due to TOD initiative have already been explored in the literature. Kahn (2007) presents results from an extensive study spanning 14 cities that have implemented TOD initiatives. The author utilizes home price and demographic data for the neighborhoods affected by rail transit access and compared them with similar neighborhoods without rail transit access. Since a large number of factors are shown to affect the degree of gentrification, outcomes from these studies vary significantly. For example, TODs providing *Walk and Rid*e access to transit have seen gentrification in Washington DC and Boston metropolitan areas while an absence of effects are observed in Los Angeles and Portland. The empirical evidence indicates that the level of gentrification is associated with the appreciation in the property values due to transit access, and as indicated by Bowes and Ihlanfeldt (Bowes and Ihlanfeldt 2001), this itself is a multi-factorial problem. While acknowledging the potential harmful effects of TOD initiatives in causing gentrification, Poticha (2007) has pointed to the possible lack of mitigation tools in many of the TOD projects. The degree of impact on vulnerable populations is reliant upon the large number of individual factors that intervene in this process as well as their interactions and interrelationships. This makes the problem of accessing and mitigating such effects more complex.

### 1.2. Critical Factors Underpinning Healthcare and Livability on Transit Corridors

The mobility within the transit corridor is centered on a high quality public transportation system such a rail (light or heavy) or a bus. Having an easy access to transit stations is fundamental to mobility. This preference is evident from the positive rise in the cost of the properties in the vicinity of the transit stations (Bajic 1983; Armstrong 1994; Gibbons and Machin 2005; Hess and Almeida 2007). A study by Chen et al.(1998) has reported that the positive effect of accessibility on property values dominates the negative impacts due to noise, pollution and criminality in case of Portland, Oregon. However, a study by Bowes and Ihlanfeldt (2001) conducted in Atlanta, Georgia, indicates that the magnitude and direction of the impact of transit access on property values may also depend on other factors such as retail activity, crime, noise, pollution and traffic associated with the stations. Smith and Gihring (2006) call for the resulting value of this positive linkage between transit access and property values to be captured for transit projects financing.

Accessibility is the most important and well-studied issue analyzed in livability communities. A safe, open and convenient pedestrian environment is the basic requirement for a pedestrian friendly transit corridor. For example, Schlossberg and Brown (2004) present 12 geographic information based on walkability measures to visualize and quantify the pedestrian environments. Other important design factors related with walking distance and building site design are found in (O'sullivan and Morrall 1996; Bernick and Cervero 1997; Nelson, Niles et al. 2001; Zimring, Joseph et al. 2005; Samuelson 2009; Miller, Hoel et al. 2010). Various investigations have analyzed the interaction between land use and transportation system (Hanson 1995; Rodrigue 1997) while the model of interaction between transportation and public health and quality life has drawn plenty attention (Frank 2000). Despite the interactions between the transit systems and land use, the topic of gentrification resulting from TOD initiatives has been unexplored.

## 2. RESEARCH QUESTION

Literature that explores the impact of livable transit corridor development on the healthcare of vulnerable population is limited. This research is extremely important in view of the recent popularity of TOD initiatives and the possibility of adoption of these projects on a larger scale. The purpose of this research is to identify key factors and relationships that impact this process and create a framework wherein this system can be modeled and simulated. An important outcome of this exercise is the identification of areas for empirical research that is not yet available. Further, this model enables a generic understanding of the processes that affect gentrification and hurdles to healthcare access. The proposed model may become a basis for numerous experiments within the cost and practicality constraints.

The system at hand is complex and has a number of intricate feedback effects associated with it. For example, the negative impact of healthcare access may lead to deterioration of health condition which imposes

economic challenges that aggravate vulnerability and lead to further reduction in healthcare access increasing disparity. Similarly, investment in transit system may advance the local economic development for affected neighborhoods and surrounding areas. This may provide more resources for further development of transit systems. The presence of such relationships makes system dynamics an ideal choice as far as the modeling paradigm is concerned.

Maintaining the affordability of the housing in such corridors for medically fragile populations is a potential strategy for mitigating such negative impacts. However the positive pressure on housing prices in the corridor region means increasing subsidies to make such policies feasible. The nature and magnitude of such and other initiatives can only be ascertained when adequate research on the lines as proposed here becomes available. A framework capable of assessing potential interventions in this setting is necessary.

## 3. RESEARCH APPROACH

The concept *livability* may encompass multiple qualitative attributes of a community's quality of life, including physical and mental well-being, educational and employment opportunity, recreation, built environment, safety, and political efficacy. An ideal characterization of a livable community with a well-being focus includes concepts of representation and responsiveness in the planning and policy generation processes, proximate access to safe public transit, green space, and improved air quality, among others. This includes a supporting system in which vulnerable population groups are protected and intervention strategies may be timely identified. The Partnership for Sustainable Communities Sustainable (2012) describes livable communities as those that promote public health, educational opportunities, and green environmental practices, among others. Thus, the concept of livability is necessarily broad and encompasses a host of economic, social, health, and perceptual characteristics. None of these attributes of transit corridor livability may stand independent, though. That is, the conceptualization of a transit corridor as a *system* necessarily implies that the constituent parts are interrelated to some degree. For example, perceptions of safety may be a function of the built environment and improved air quality may be a function of more transportation choice; both these relationships may, in turn, contribute to a transit corridor's economic competiveness. However, as indicated before, this generates a variable degree of gentrification of vulnerable groups that depends on the location of each station and the rail line of the corridor.

It is understandable, then, that the study of such a system requires identification of these attributes as well as an understanding of how each attribute may act upon others to promote either reinforcing or balancing behavior of the overall system. It is difficult to conceptualize, let alone empirically capturing, the overall system behavior stemming from the myriad of causal relationships among these factors. It also difficult to visualize how transit policy interventions may alter livability, and in particular, public health effects, within a system, and even more difficult to understand the disparate impact such interventions may have among population and vulnerable groups or neighborhoods. System Dynamics offers an attractive approach to capturing the complexities inherent within a transit corridor system and how the system may respond to interventions. In addition, since livability is inextricably linked to the experience of place and the surrounding built environment, tools and techniques designed to address issues such as proximity, density, area, and hot spots are also essential to our approach. For example, from the health perspective, the concept of livability may include pedestrian access or walk-ability to transit service station while considering the mobility levels of each pedestrian sub-population such as elderly.

Mental models are unable to accommodate the complexity of interactions that are some distance from the immediate problem. Through a system dynamics approach, the measurement of the dynamic impacts of transit feeder interventions over time are meant to allow stakeholders (especially policy makers and traditionally underserved communities) to interpret the information differently by allowing alteration of mental models. Traditional approaches have not been well suited to anticipate the second and third order health-related consequences of competing policy options upon particular population segments (e.g., underserved communities) and, in some instances, have resulted in policy resistance (e.g., resulting in unanticipated changes in livability). Our system dynamics approach allows us to understand -- as well as anticipate -- the dynamic behavior of the population health dynamics of neighborhoods beyond the transit station area over time, particularly on those vulnerable groups, and allows us to empirically demonstrate changes in the system's behavior which may be counterintuitive or would not have been evident if approached with more traditional causal methodologies. With our proposed approach, decision makers may simulate over time the dynamic interaction and 'ripple effect' of adopting any combination of feeder transit corridor policy options and the sensitivity of various sub-populations to these interventions.

## 4. CONCEPTUAL MODEL DESCRIPTION

The conceptual model representing the dynamics described and key causal relations is introduced in this section. Figure 1 below illustrates the proposed conceptual model. A description of the dynamic hypothesis that forms the basis of the model follows.

The dynamic hypothesis is developed from the discussion based in the previous section. The causal-loop diagram presented in Figure 1 suggests that the investment in TOD projects enables the deployment of greater number of transportation resources.

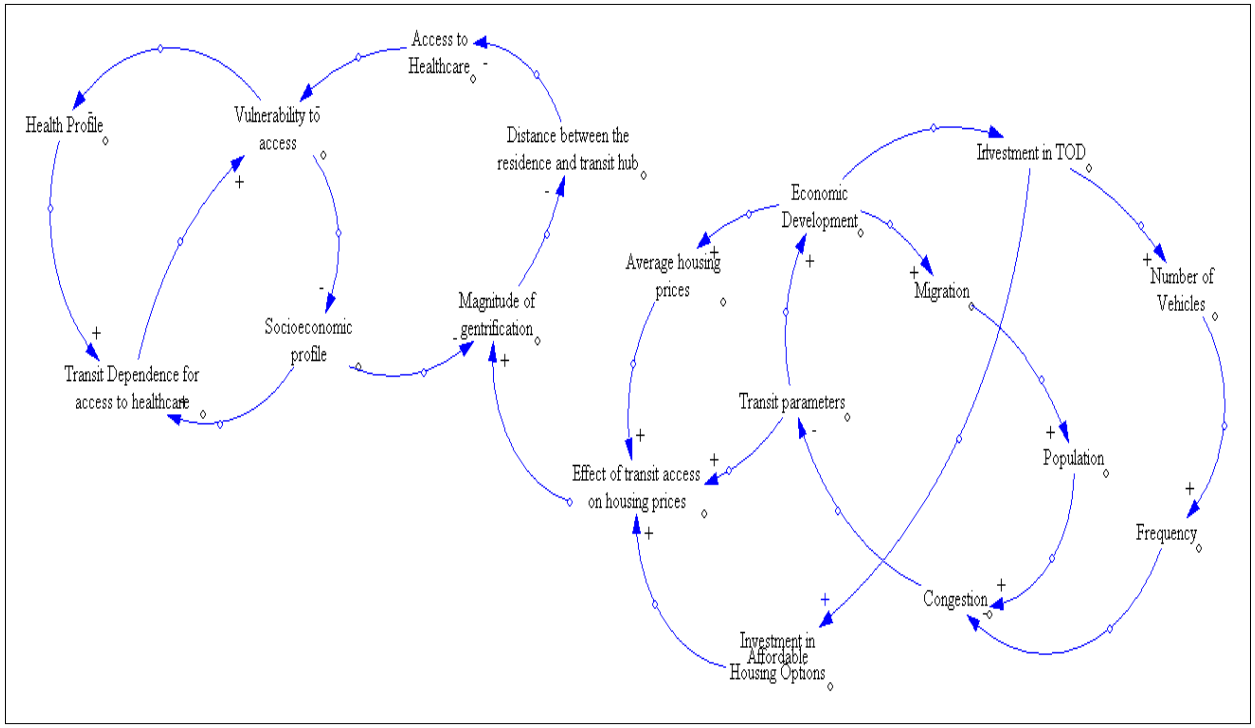


Figure 1. Causal Loop Diagram Representing the Dynamic Hypothesis

This leads to the development of an efficient transportation system. Simultaneously, the availability of efficient transportation becomes an asset for the region that attracts investments and fosters economic activity as indicated in section 1.1 and 1.2. Thus, the areas affected by the TOD solution become centers for commercial activity. The resulting employment opportunities attract migrants to the region which increases the demand for the transit and leads to congestion. However, the increasing commercial activity in the region produces a greater income in form of tax revenues for the local authorities. This income may be reinvested in the TOD or other related project that further transit development.

The effectiveness of the transit determined by the key transit performance parameters is one of the factors affecting the values of home prices in the vicinity of the transit access. Two additional important factors involve the overall trend in housing prices in the region as well as the efforts within the TOD initiatives to maintain the affordability of the housing within the corridor. Affordability of housing within TOD may be maintained by allowing higher density construction and providing subsidies to make affordable housing option available to the low-income populations. The combination of these factors determines the magnitude of change in the housing prices in the corridor.

An increase in the housing prices in the corridor may result in gentrification process of the population having a lower socio-economic profile. This process may occurs because of the increasing rents and taxes that result from the increasing house prices will be likely out of reach of these vulnerable classes. The displaced population is forced to be relocated into areas that have comparatively lower access to public transit. Simultaneously, the gentrification process may occur to those who experience mobility issues, e.g., elderly or those who suffer a chronic disease and are considered a vulnerable population. Since many spaces affected by the TOD solution are purposively design to be walk-able spaces, these vulnerable populations may find limited transporting options that cause them to leave to other areas.

As the underserved population relocate, the access to public transit is reduced while experiencing increases in their vulnerability. The reduced access leads to likely neglect their medical care and further deteriorates the health status of these vulnerable individuals. This relocation might lead to a further decline in their socio-economic profile, e.g., a longer commute may increase transportation expenditures jeopardizing job continuity. Figure 2 presents a stock and flow model that implements this dynamic hypothesis. The model is then simulated under hypothetical conditions to determine its behavior. The results of the simulation are presented and discussed in the next section.

## 5. RESULTS

The model is executed for an experiment wherein the 'Investment fraction in affordable housing' is alternated between 0.001 (scenario 1) and 0.005 (scenario 2). This fraction represents the relative portion in TOD investments dedicated to subsidizing or making available, through a generic theoretical intervention, affordable housing to the disadvantaged. Notice that the values used in these experiments are theoretical.

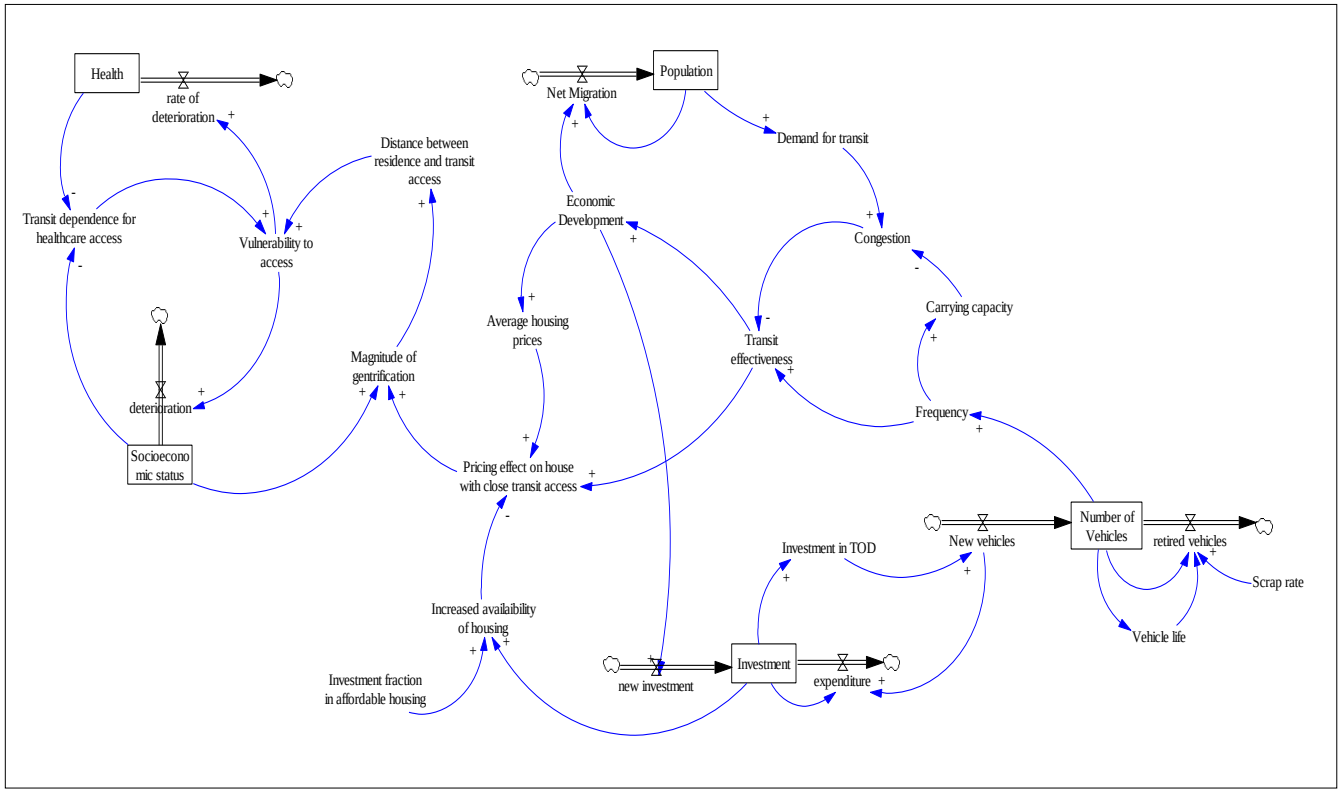


Figure 2. Stock and Flow Model

These hypothetical values do not represent anything and they are just used to explore the theoretical behavior. The resulting system behavior is based on our synthetic representation of a real-world situation. Thus, at this stage, we are seeking to mimic the behavior of each synthetic variable according to its corresponding real-world representation without focusing on accurate levels of the variable. The refinement and calibration of the model will be executed on subsequent research activities.

The fraction indicated above may potentially represent a relative mitigation of the gentrification process. Figure 3 below illustrates the trend in *vulnerability to access* under the scenarios mentioned above where the continuous line represents the scenario 1 while the segmented line represents the scenario 2. As expected in this theoretical model, it is observed that increasing the allocation funds for affordable housing within the TOD projects reduces the vulnerability to healthcare access over time.

The opposite is true when relatively fewer or none funds are allocated for this purpose. A similar trend is seen in the *Socio-economic status*. Availability of affordable housing within the TOD corridor leads to an improvement in the socio-economic status due to increased access to both healthcare and economic opportunities. Conversely, a lack of funding is likely to lead to gentrification and possible deterioration of socio-economic status due to reduced access to healthcare and the resulting disadvantage from employment perspective.

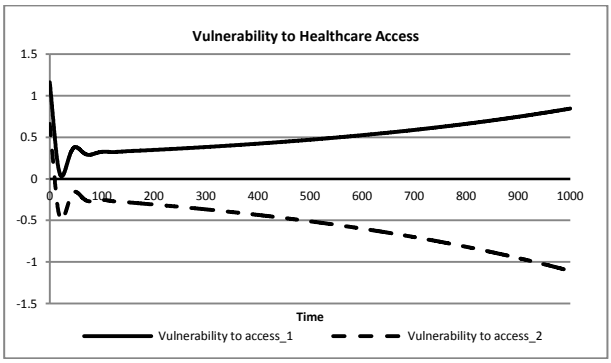


Figure 3. Vulnerability to Reduced Healthcare Access

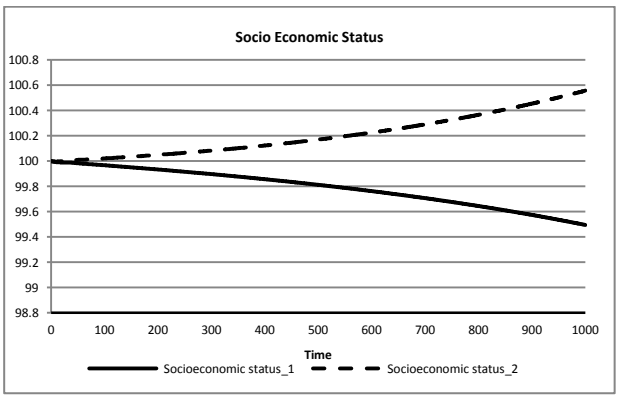


Figure 4. Socioeconomic Status

The level of transit effectiveness within the TOD corridor is reported in Figure 5. The transit effectiveness is expressed as a function of the demand for transit and the available capacity of the transit. The available capacity of transit is characterized as the function of the transit frequency for a constant per trip carrying capacity. Figure 6 illustrates the trend for the price of houses close to the transit locations. The trends are influenced by the proportion of funds available from affordable housing initiatives. Adequate funding levels allocated to affordable housing in the TOD corridor have the capability of mitigating the negative impact of transit access on housing prices and help keeping average housing prices controlled. An absence of such initiatives is likely to result in a price increase in the TOD corridor housings, as transit access is increasingly seen as a useful feature of houses in transit vicinity.

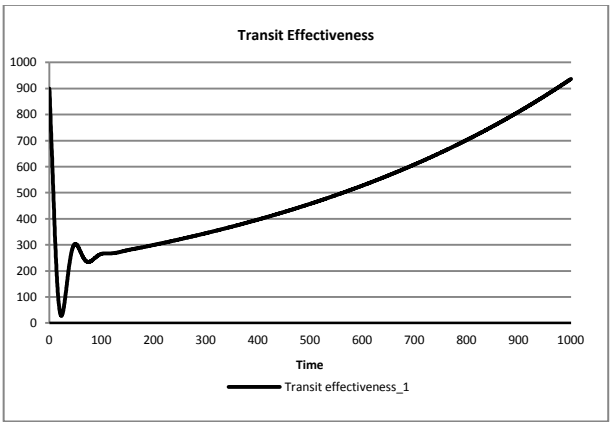


Figure 5. Transit Effectiveness

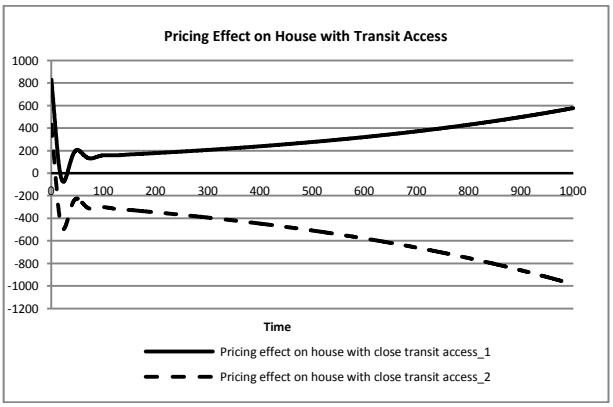


Figure 6. Pricing Effect of Transit Access on Housing Prices

## 6. CONCLUSIONS

An important linkage between transit oriented development and healthcare access is highlighted in this paper. While TOD is likely to improve healthcare access to the general population by providing reliable transit, its impact on the most vulnerable segments of the population are uncertain. Some studies have shown that TOD initiatives may potential lead to gentrification under certain conditions. The present study focuses on the modeling of critical factors that characterize this relationship and the characterizing of the links between these factors and their representation using a system dynamics approach. The use of system dynamics as the modeling paradigm is justified by the presence of considerable complexity and feedback in the system under consideration.

The study by Kahn (2007) shows that gentrification in TOD initiatives is not universally observable and depends on numerous factors. Thus, the effect of TOD on the healthcare access of vulnerable populations is likely not to be generic and dependent on numerous variables and their dynamics. A common understanding of effects of a particular set of factors may have on the implementations of TOD projects and potential gentrification processes is lacking. The purpose of the modeling exercise in this paper is to create a platform wherein relevant factors may be modeled and simulated. Thus, a framework that enables a more generic understanding of the effects of TOD on healthcare access of vulnerable population may be created.

While endeavors in the creation of such a model are described in this paper, what is lacking is the empirical analysis necessary to validate the model behavior. Therefore, a critical step in the extension of this work involves development of case studies that empirically analyze the impact of TOD on the healthcare access of vulnerable population. These results may be used to refine and validate the model proposed above. The model may be then used to understand the possible systemic implication (first- and second-order effects) that various scenarios of input factors can create. The model may thus become a useful tool for generalizing the outcomes from these analyses such that they may be employed for predictive studies in future projects. Further, this tool may be prospectively transformed into a training tool that provides an educational platform for understanding the effects of TOD implementations on health inequalities as well as a means for exploring interventions that assist in mitigating the impact of gentrification processes.

In addition this work demonstrates that can be extended to suburban TODs environments (Rodriguez, Khattak et al. 2006; Baran, Rodríguez et al. 2008; Brown, Khattak et al. 2008) which is an ongoing investigation for the authors.

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