The impact of rail transit investment on the residential property values in developing countries: The case of Izmir Subway, Turkey

Article *in* Property Management · August 2006

DOI: 10.1108/02637470610671604

H. Murat Celik
Istanbul Technical University

The impact of rail transit investment on the residential property values in developing countries

The case of Izmir Subway, Turkey

Received March 2005
Revised August 2005

H. Murat Celik
Izmir Institute of Technology, Department of Civil Engineering, Izmir, Turkey, and

Ugur Yankaya
Izmir Institute of Technology, Department of City and Regional Planning, Izmir, Turkey

Abstract

Purpose – The purpose of this paper is to test whether the rail transit investment in Izmir, Turkey has had positive valuation impacts on the surrounding residential properties, and to estimate the value of travel time using relevant parameters.

Design/methodology/approach – The necessary data were collected via a survey including all real-estate agents in the area. To test the research question, the Hedonic Price Model (HPM) is used as the research technique. The obtained parameters are also used to estimate the value of travel time.

Findings – The findings of the models has indicated that the proximity to rail stations was valued at $250-300 per meters, and the value of travel per hour was $1.47-1.83 on average.

Research limitations/implications – These findings should be checked with more consistent database using transaction process, and the mortgage loan rate which was not legislated at the time of study.

Practical implications – Until a mortgage loan rate is registered in turkey, the estimated parameters can be used in the cost-benefit analysis of rail transit investments in Turkey.

Originality/value – The theoretical premise that "any improvement in accessibility will be capitalized into the land values" is tested one more time in a developing country case whose urban environment is substantially different from those of the developed world, especially the North American cities. Furthermore, a new methodology using the HPM parameters is also suggested to estimate the value of travel time.

Keywords Developing countries, Rail transport, Inward investment, Residential property, Turkey

Paper type Research paper

1. Introduction

The theoretical premise that "any improvement in transportation infrastructure is capitalized into land values in a short-term urban partial equilibrium" (Alonso, 1964; Muth, 1969; Mills, 1972) has been tested extensively in different empirical settings by many authors using various techniques. The examined transport infrastructures include new highway investments, capacity improvements in existing highway

Property Management
Vol. 24 No. 4, 2006
pp. 369-382

0263-7472
DOI 10.1108/02637470610671604

networks, new transit facilities, and different improvements in existing transit stocks. The realized impacts were monitored from the perspectives of income, employment, population, land use, density, and monetary value changes in different urban sectors such as industrial, commercial, office and different types of residential uses. Temporal perspectives of these effects in the studies also varied from short to long-terms. Even a modest review of this literature would be voluminous to present here. Considering the scope of the present study, we confine ourselves to the examination of the rail transit investments impact on the residential property values using the Hedonic Price Model (HPM) and relevant literature.

Even though the authors studying the rail transit impacts have reached varying results in their findings, the urban environments they were examining shared certain similarities. First of all, these urban settings in the literature mostly took place in the developed economies. Furthermore, the North-American cities dominate the literature (Cambridge Systematics Inc., 1998): San Francisco (Cervero and Landis, 1997; Knight and Trygg, 1977), Los Angles (Cervero and Duncan, 2002), Atlanta (Bollinger and Ihlanfeldt, 1997; Cervero, 1994), Washington DC (Cervero, 1994), Miami (Gatzlaff and Smith, 1993), Toronto (Dewees, 1976; Bajic, 1983), and Portland (Al-Mosaind *et al.*, 1993; Chen *et al.*, 1997). Hong Kong (So *et al.*, 1997; Chau and Ng, 1998), Manchester (Forrest *et al.*, 1996), Sheffield (Henneberry, 1998), and Helsinki (Laakso, 1992) are the other cities with rail transit investments in developed countries.

The most important reason for this dominance in the literature is that the rail transit investments mostly appear in richer developed countries due to high initial cost requirement of such investments. It is a known fact that the rail transit industry is characterized by increasing returns of scale implying a large amount of output with constantly decreasing marginal and average costs. This may make the short-term profitability of such investments fragile and often requires public sector funding. Considering the low capital accumulation and the resources of the developing countries, especially in the public sector, expensive infrastructures like rail transit are either ignored or postponed until a convenient (mostly international) source of financing is obtained. Up to that point, the public transit is served by publicly or privately-owned buses and jitneys mini-buses which require lower short-term, but higher long-term costs, and work generally under constant or decreasing returns of scales implying economical inefficiency. Thus, the more expensive public transit investments are more common in developed part of the world than those of developing countries. Even if there were occasionally such investments in developing countries, monitoring and measurement of the temporal impacts and interactions of these types of investments with their urban environments necessitate a consistent and sufficient database which is often a big problem in many developing countries.

The intention of this paper is to curb this dominance by reporting the immediate impacts of a rail transit investment, namely the Izmir Subway, on residential property values as a case study from a developing country, Turkey, using an HPM. In this sense, the novelty of this paper is to examine the very well-known premise of the urban economic theory in a substantially different socio-economic, geographic, and geometric urban setting empirically. Beyond examination of the theory, a set of parametric values for the searched elasticities are also reported with the intention that these values would be helpful for decision-makers in their cost-benefit analyses, and for scholars in future comparative studies. Furthermore, we also use a value capitalization technique to derive the value of travel time as a new approach using walking distance. As stated earlier, the dearth of information concerning developing countries on this subject makes the text valuable. The next section of the paper is devoted to the relevant literature review. The model is explained in the third section. The section four describes the study area and the data used in the study. The findings of the study are reported in the fifth section, and the section six concludes the paper.

2. Literature review

Theoretical studies in urban economics have long been discussing the linkages and interactions between the transportation investments and urban structure. Pioneering studies by Alonso (1964), Muth (1969), and Mills (1972) have modeled a mono-centric city and assumed that all the employment took place at the city center. In this configuration, the variation in commuting time would be the major determinant of the city rent curve, *ceteris paribus*. The rent is expected to be highest at the center, reflecting the saving in commuting time, and the lowest at the city boundary where the cost of commuting is deducted from the rent, with identical households locate uniformly in-between depending on their utility functions. However, simple, these models helped us establish our fundamental understanding that land rent reflects the opportunity cost of transportation. Furthermore, any improvement in transportation infrastructure that could lead to a decline in travel cost which would be capitalized into land values, holding everything else constant. Obviously, the term "holding everything else constant" implies a short-term partial equilibrium. On the other hand, a long-term equilibrium, where everything is considered variable, is more vague, difficult to model, and highly contextual (Henderson, 1988; Fujita, 1989). If, for example, the city boundary is allowed to change, an improvement in transport infrastructure will cause a decline in the land curve and in the general equilibrium, since the improved transport will lead to a city expansion associated with an increase in land supply.

While short-term effects can easily be measured by monitoring the changes in the land rent curve, the long-term effects of transportation improvements reflect themselves in other indicators, including land-use, density, population, employment, income and developmental changes as well as the changes in the rent curve. Furthermore, the revelations in all these indicators may be very different in different urban settings, leading to a possible divergence in the urban economic theory. Nonetheless, we can see the efforts to monitor the long-term effects of transit investments from different perspectives in cities even if they are more limited than the efforts of evaluating the short-terms consequences. Cervero and Landis (1997), for example, evaluated the long-term effects of San Francisco's Bay Area Rapid Transit (BART). The other studies: Bollinger and Ihlanfeldt (1997) about Atlanta's MARTA (Metropolitan Atlanta Rapid Transit Authority); and Cervero (1994) about the Washington DC Rail System and MARTA are only a few examples of the studies addressing the long-term consequences of rail transit investments. These studies sought to monitor the changes by examining also the land use, population, employment, developmental changes around stations and transit corridors, and none of them was confidently able to unveil the long-term additive effects of the rail transit investments. It was reported that even though there were certain developments around and along the rail facilities, these developments were weakly attributed to the rail investments. These results obviously seem counter-intuitive. However, it should be noted that the findings did not prove the contrary either. Since it would not be possible to say how the development and change would be if there had not been such rail developments, the issue cannot be reconciled precisely. For that reason, these careful conclusions by the studies are attributed to their authors' scholarly discretion. Obviously, there are many questions to be studied on the long-term impacts of rail investments.

The short-term impact studies using HPM generally examine the land rent variation due to the transit investment. The dependent variable is the price of the property (either asking or transaction price). Three vectors of variables: property characteristics; neighborhood characteristics; and access or location variables are included as the independent set in the equations. Access variables are specified in three general forms: the physical distance to transit stop or transit line (Henneberry, 1998; Chen *et al.*, 1997; Al-Mosaind *et al.*, 1993; Gatzlaff and Smith, 1993), a dummy variable specifying that the property is located within a given distance (Forrest *et al.*, 1996; Laakso, 1992; Chau and Ng, 1998; Al-Mosaind *et al.*, 1993; So *et al.*, 1997; Cervero and Duncan, 2002) or the total travel time to transit stop or a desired destination (Dewees, 1976; Bajic, 1983). Theoretical intuition for the physical distance and travel time variables would be negatively correlated, and the distance dummy positively correlated with the property value. While a dummy variable discretely determines the effect of rail transit, the physical distance or travel time variables allow the decision-makers to use estimated parametric elasticities in their decisions as well as to use them in derivation of the value of travel time (Bajic, 1983).

The empirical testing of the theory is generally done via significance statistics of the estimated parameters. It is possible to say that the theory is not confirmed uniformly in all studies. While some studies found a significant positive impact on property values (Chen *et al.*, 1997; Al-Mosaind *et al.*, 1993; Chau and Ng, 1998; So *et al.*, 1997; Dewees, 1976; Bajic, 1983; Laakso, 1992), some others were not able to identify any significant positive effects (Gatzlaff and Smith, 1993; Henneberry, 1998; Forrest *et al.*, 1996). The chosen functional forms in all the studies mainly included linear and log-linear, although in a few cases Box-Cox (Chau and Ng, 1998) specifications is also used. Goodness of fit, R^2 for the models varied between 0.52 (So *et al.*, 1997) and 0.94 (Laakso, 1992), but were generally around 0.70. As a general evaluation, it is not possible to make a useful elasticity and parameter comparison across studies since the monetary units, time periods, specifications in distance variables, and functional forms are different in each of the studies. These general points also indicate that, not only do the short-term effects of rail investments not display uniformity, but that they could also be very contextual. Furthermore, it should be noted that cities from developed countries, especially the North American cities, share certain similarities, and are substantially different from cities in developing world. Cities in developed countries are geographically more sprawled in general, and require longer rail-tracts; land-uses are more distinct and homogenous due to a larger land supply and strictly enforced zoning regulations; and land-use densities in residential areas are lower in comparison to cities in the developing world. All these differences make the theory worth testing in a different urban setting for its short-term impacts.

3. Model

The Transit Cooperative Research Program (TCRP) Report 35 (Cambridge Systematics Inc., 1998) classifies the impacts of rail transit investments under three headings: generative impacts; redistributive impacts, and financial transfer impacts. Several methods impacts and their properties are discussed in the report. These methods include:

- multiple regression and econometric models;
- area-wide transportation models;
- benefit-cost analyses;
- input-output models;
- economic forecasting and simulation models;
- statistical and non-statistical comparison models;
- focus groups survey methods;
- physical condition analyses;
- real-estate market analyses; and
- fiscal impact analyses.

The impact of transit investments on property values is considered as a generative impact. To measure the generative impacts, the multiple regression and econometric models, and the statistical comparison models are recommended techniques.

The statistical comparison techniques would require a reliable time series data and relatively stable economic environment and real estate markets. A reliable time series database on this subject is not available in Turkey. Furthermore, the macro-economic crises in 1999 and 2000 have shaken the whole economy. The devaluation of Turkish Lira has destabilized all prices in all markets, especially in the real-estate markets. Even if a reliable time series data for the real-estate market was available, this type of modeling could not be used because of the price destabilization in the real-estate markets after the economic shocks that last up to the present day.

To isolate all other effects, a cross-sectional HPM, which is a special form of multiple regression and econometric model, is used in this study. The usage of HPM for estimating housing demand was justified by Rosen (1974). The HPM is extensively used to estimate property demand and property values with respect to certain amenities either within the property, or around its environment. According to HPM, the value of housing is made of three sets of attributes: the property attributes; the neighborhood attributes; and locational or accessibility attributes. Thus:

$$P = f(H, N, L, \beta, \varepsilon) \tag{1}$$

Where P is the price of the property, H is the vector of variables specifying property characteristics; N is the vector of variables specifying neighborhood characteristics; L is the vector of variables specifying the location of the property; β is the vector of estimated parameters; and ξ is the random error term.

Earlier studies generally use linear or log-linear (exponential) functional forms (Henneberry, 1998). The marginal effect of a change in a specific variable on the price is obtained by the partial derivative of the equation with respect to that variable. In linear form, this derivative is equal to the estimated parameter of the variable at stake:

$$\frac{\partial P}{\partial z_i} = \beta_i \quad (2)$$

In other words, the estimated parameter in linear form is the relative price of the specific attribute of the property. Naturally, this is a linear measure and assumed fixed for all properties. In some cases, however, neat, this linearity assumption may not make sense, and a significant attribute is expected to display variations proportional to the value of the property at margins. In such cases, log-linear (exponential) functional form allows the analyst to include the value of the property at margins:

$$\frac{\partial P}{\partial z_i} = \beta_i P \quad (3)$$

In the present study, we also prefer to use two traditional functional forms: linear and exponential. In terms of variables, two sets of variables, property characteristics and locational variables are used. The spatial configurations, population densities, urban landscape and environmental qualities of two neighborhoods are not substantially different. For this reason, it was not possible to devise a set of variables measuring the neighborhood characteristics, and they were omitted in the models. Variables measuring property characteristics include three continuous variables: the size of the apartment (size) in square meters, the age of the apartment building (age), the height of the apartment building as storey number (fltnmbr); and three dummy variables: if the apartment building is a corner building in the block (corner), if the apartment building has a central heating system (heater), and if the apartment is decorated with the high quality construction materials (quality). Obviously, these property variables included in our models were not the only variables in our database. However, insignificant property variables are eliminated from the models, and the final models are estimated with only significant ones in order to obtain parametric efficiencies, especially for the locational variables. Two locational variables are included in the model: one being walking distance to the nearest rail-station in meters (subdist); and the other one being walking distance to the nearest bus-stop (busdist) which is the competing and conventional transit mode in the area and throughout Turkey for that matter. Locational variables are expected to be negatively correlated with the price while all variables measuring the property characteristics, except for age, are expected to be positively correlated. In short, the model used in the study can be expressed as

$$P = f(\text{subdist}, \text{busdist}, \text{size}, \text{age}, \text{fltnmbr}, \text{corner}, \text{heater}, \text{quality}) \quad (4)$$

4. Description of study area and data

The study area, Izmir, is the third largest metropolitan area of Turkey after Istanbul (10 millions) and Ankara (3.6 millions), and is located at the western part of the country on the Aegean Coast (Figure 1). Public transit in all Turkish cities is provided by bus fleets, owned mainly by local municipalities, and minibuses ply as jitneys, and are operated by private parties. Turkey has recently changed its public transit policy towards rail-transit systems, and completed a first phase of rail-transit services in three major metropolitan areas by the year 2000.

The current population of Izmir city is around 2.8 millions. In 2010, a total population of 4 millions is projected in the metropolitan area, 47 percent of which is

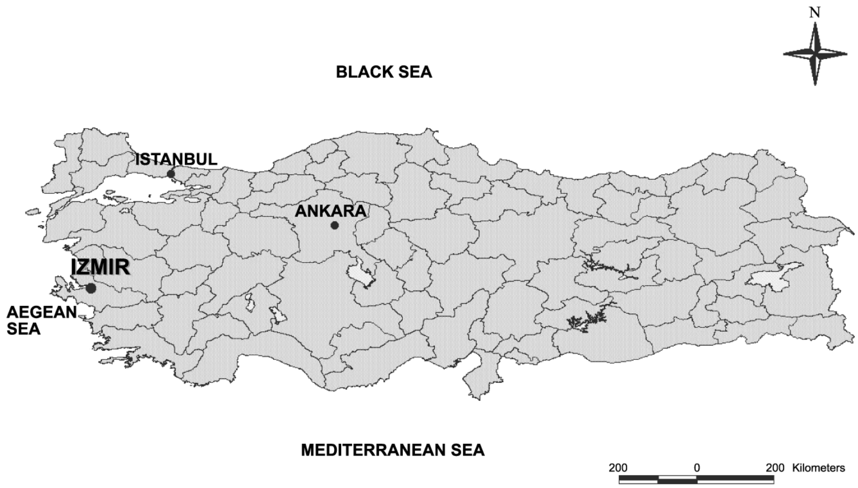

Figure 1.
Major metropolitan areas of Turkey

expected to commute daily to the city center. The Commuter-Rail Master Plan by Izmir Municipality projected a total of 50 km track-line in 1992, and intended to connect four outer counties, Narlıdere, Buca, Bornova, and Cigli to each other and to the city center, Konak where CBD is located (Figure 2).

The construction of the first phase started in 1993, and was completed in August 2000. The length is 11.7 km, and connects Ucyol residential area to the CBD, and

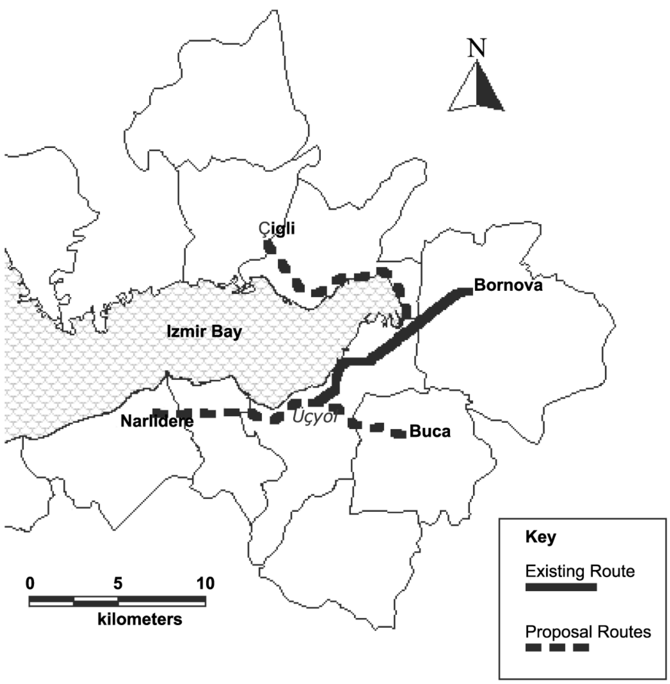

Figure 2.
Existing and proposed lines for the Izmir Subway

Bornova County. There are ten stations on the line: Ucyol, Konak, Cankaya, Basmane, Hilal, Halkapınar, Stadyum, Sanayi, Bolge, and Bornova. The line connects major business, industrial and residential areas in the city (Figure 3). The major residential neighborhoods are concentrated around Ucyol and Bornova Districts where the real estate agent survey was conducted. The total residential population in the impact area of the line is around 422,000, and approximately a 1,435 ha residential area is served by the existing line. The gross residential density in the service area is around 300 persons/hectare, which can be considered very high in comparison to North American cities. All of this population resides in high rise (3-11 storey) multi-family apartment buildings. Additionally, major industrial, commercial, and educational zones of the city are served by the existing line: i.e. approximately 500 ha industrial, 257 ha commercial (141 ha of which is the CBD), 300 ha Aegean University Campus (located at Bornova Station), 236 ha Public Agencies, 50 ha of an international fair area, and a football stadium.

In a sense, the spatial configuration around the existing line is very similar to a theoretical mono-centric city: two important residential areas, and an important educational facility as a special travel generator at the terminal points, and urban employment areas in-between. It has been more than four years now since the subway went into operation. This time span is considered long enough to realize the short-term impact of the rail-line on the property market. The area around the line is already densely occupied. For this reason, it would not be reasonable to expect any land-use or density changes in this short-term since the construction activities leading to land-use and density changes will require relatively longer periods. However, the saving perceived right after improved access by the line could be reflected either in monthly rent paid for the properties in the subsequent lease term (which would be one year at most) or in immediate selling prices. Eventually, the most immediate impact to expect in the area would be a change in the rent curve as a right shift.

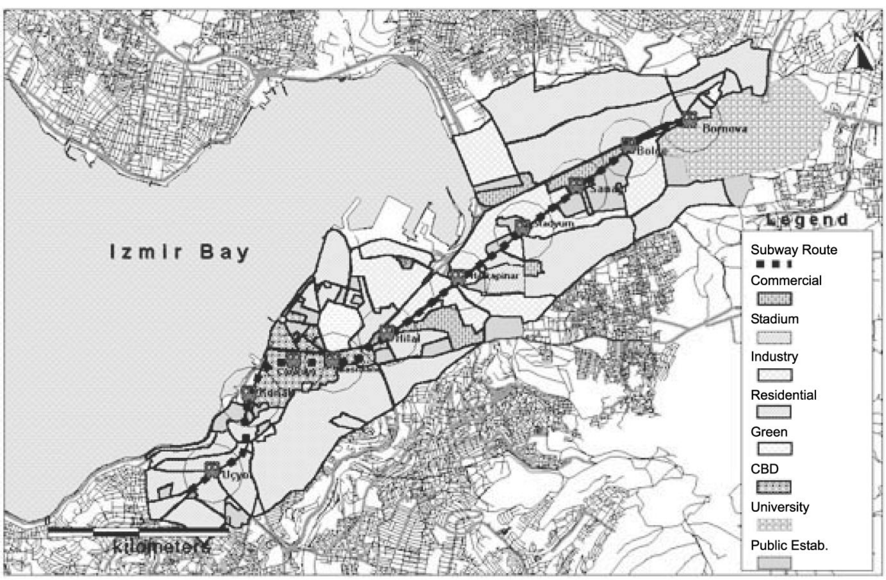

Figure 3.
Land use around existing subway line

The data used in this study were collected through a survey including all real-estate agencies in the area from December 2003 to March 2004, since there is no other dependable database concerning real-estate transactions in Turkey. Even though it could be possible to monitor the real-estate transactions from the deed records, this database is not very dependable due to under-declarations of transaction prices, and it would not be possible to obtain all necessary variables for the study, such as asking prices before transaction took place, and the other property characteristics. Data included a total of 360 multi-family residential units in the whole area, 187 of them from Bornova District (Northern Terminal) and 173 of them Ucyol District (Southern district).

The dependent variable in the HPMs include transaction prices, valuation prices by values and asking prices by the owners or realtors. Each of them has certain advantages and disadvantages for using in the HPMs (see Henneberry, 1998 for details). The dependent variable in this paper was asking price rather than actual transaction prices, which are not available in Turkey. Furthermore, the correlation between asking prices and transaction prices has never been the subject of any previous study in Turkey. Beyond its advantages and disadvantages, asking prices as the choice of dependent variable is only a matter of convenience and there is no assertion about an anticipated correlation with clear outliers.

The asking prices are converted to the US dollars to make an international comparison possible. The daily average exchange rate during the four month period while the survey was conducted was 1,350,670 Turkish liras for one US dollars. With this rate, the mean price came to $37,610 for the whole area; $43,122 for the Bornova district; and $31,652 for the Ucyol district. All variables concerning the property characteristics are obtained from the survey, and distance variables are estimated as walking distances in meters using digital maps of the areas. The descriptive statistics for the variables used in the equations is presented in Table I.

5. Results

Two models: linear and exponential forms are estimated for three areas: two for both districts, and one for the whole area. Their results are presented in Tables II and III, respectively. It should be noted that the signs of the coefficients confirm our initial expectations. Beyond that, most of the estimated parameters are significant at 95 percent confidence interval. According to the linear model, the most significant determinant of the property value is constituted by the size of the apartment, and each additional square meter has added approximately $250-300 to the price in the study area. The age of the building was negatively correlated with the price. Each year reduces the price by $195. However, this variable is not highly significant in the district equations. The apartments in high-rise buildings are priced higher. This may stem from the fact that the relatively newer buildings are higher due to technological development in the construction industry. In the same way, the apartments in buildings located at the corner of building blocks are priced $3,151 higher than the others. Furthermore, the apartments with a higher material quality and with central heating system instead of stove heating priced higher at $5,507 and $4,684, respectively.

The main finding of the study has indicated that walking distance to the nearest subway station was negatively correlated with the property price, and this correlation is highly significant in all equations. Each additional meter a way from subway station decreased the price by $4.76 in the whole area, $5.19 in the Bornova district, and $18.70

	N	Mean	St. Dev.	Min	Max
Whole area					
Price	360	37610.31	14439.04	8096.15	69921.32
Subdist	360	535.21	323.99	20.00	1610.00
Busdist	360	208.52	119.86	15.00	736.00
Bustvt	360	311.54	16.17	293.51	333.54
Subtvt	360	81.76	3.66	73.53	92.70
Size	360	112.34	23.46	65.00	186.00
Age	360	16.97	7.25	2.00	35.00
Flatnmbr	360	6.08	1.56	3.00	11.00
Bornova district					
Price	187	43121.76	12391.40	22080.00	69921.00
Subdist	187	696.78	323.92	119.00	1610.00
Busdist	187	238.8	119.28	40.00	736.00
Bustvt	187	296.07	1.53	293.51	302.46
Subtvt	187	80.96	4.16	73.53	92.70
Size	187	119.12	23.02	70.00	180.00
Age	187	13.74	5.04	2.00	34.00
Flatnmbr	187	6.41	1.41	3.00	10.00
Ucyol district					
Price	173	31652.85	14155.79	8096.15	69921.00
Subdist	173	360.56	215.79	20.00	824.00
Busdist	173	175.80	111.93	15.00	586.00
Bustvt	173	328.26	1.43	326.19	333.54
Subtvt	173	82.63	2.77	78.26	88.60
Size	173	105.02	21.71	65.00	186.00
Age	173	20.46	7.64	2.00	35.00
Flatnmbr	173	3.24	2.06	1.00	8.00

Table I.
Descriptive statistics for study area

	Whole area ($R^2 = 0.70$, White = 252.00, $F = 105.12$, F Prb. = 0.000)			Bornova district ($R^2 = 0.73$, White = 136.51, $F = 60.24$, F Prb. = 0.000)			Ucyol district ($R^2 = 0.75$, White = 129.75, $F = 61.13$, F Prb. = 0.000)		
	β	t	t Prb.	β	t	t Prb.	β	t	t Prb.
Intercept	−6435.00	−1.86	0.064	13054.00	2.71	0.007	632.16	0.13	0.893
Subdist	−4.76	−3.24	0.001	−5.19	−3.27	0.001	−18.70	−6.17	0.000
Busdist	−1.80	−0.46	0.647	−6.79	−1.50	0.136	−12.42	−2.22	0.028
Size	297.98	13.76	0.000	267.44	9.81	0.000	252.98	8.78	0.000
Age	−195.42	−2.95	0.003	−177.00	−1.66	0.099	−47.31	−0.60	0.551
Fltnmbr	1759.55	5.53	0.000	−128.49	−0.33	0.743	1810.22	4.04	0.000
Corner	3151.04	3.45	0.000	1977.52	1.76	0.080	2112.82	1.78	0.077
Heater	4684.26	4.39	0.000	4450.96	3.77	0.000	4379.38	2.88	0.005
Quality	5506.69	5.79	0.000	6381.12	5.73	0.000	4255.59	3.35	0.001

Table II.
Results of linear model

in the Ucyol district. While these sensitivities are close to each other in the whole area and the Bornova district, the Ucyol district demonstrates a much higher (almost four times higher) sensitivity to the distance. There could be two possible explanations for this situation:

	Whole area ($R^2 = 0.68$, White = 244.80, $F = 92.827$, F Prb. = 0.000)			Bornova district ($R^2 = 0.75$, White = 140.25, $F = 68.663$, F Prb. = 0.000)			Ucyol district ($R^2 = 0.74$, White = 128.02, $F = 58.692$, F Prb. = 0.000)		
	β	t	t Prb.	β	t	t Prb.	β	t	t Prb.
Intercept	9.18686892	87.88	0.000	9.847764114	90.99	0.000	9.395357388	62.29	0.000
Subdist	−0.00011821	−2.66	0.008	−0.000133679	−3.74	0.000	−0.000584961	−6.00	0.000
Busdist	−0.00006975	−0.59	0.558	−0.000115124	−1.13	0.261	−0.000555575	−3.09	0.002
Size	0.00846359	12.96	0.000	0.006694452	10.92	0.000	0.008120138	8.76	0.000
Age	−0.00627237	−3.14	0.002	−0.002832986	−1.18	0.240	−0.002654199	−1.04	0.299
Fltnmbr	0.05473372	5.7	0.000	−0.001223815	−0.14	0.890	0.042907060	2.98	0.003
Corner	0.09971450	3.62	0.000	0.034843470	1.38	0.170	0.087296346	2.29	0.023
Heater	0.11521668	3.58	0.000	0.103046393	3.87	0.000	0.142098202	2.90	0.004
Quality	0.14661044	5.11	0.000	0.155535708	6.21	0.000	0.131318449	3.22	0.002

Table III. Results of exponential model

(1) About 68 percent of all observations were located within 575 m from a station while this is 855 m for the whole area, and 1020 m for the Bornova district. In other words, the spatial configuration of the Ucyol district is more concentrated around rail stations; and

(2) the Ucyol district may have higher proportion of the population using the transit than the rest of the study area.

This fact needs to be studied more in-depth as part of another study. The sign of the bus-stop distance variable is also negative in all equations. Even though the bus transit is older and a more conventional mode, it does not display a significant effect on the property values, and was only significant for the Ucyol district, possibly due to the reasons just stated. These findings about the locational variables are also confirmed by the exponential models, and it would not be useful to restate them here. The parameter estimates of the exponential models are given in Table III.

The goodness of fit statistics, R^2 for the models lies between 0.68 and 0.75. This can be considered as relatively higher and comparable to those of earlier studies. The F statistics, testing the significance of the variable set altogether in the equations, demonstrated that the variables were significantly different from zero and relevant altogether. To check if the error terms showed homocadastic variances, a White Test is conducted for each equation. As stated by Green (1997, p. 550) the White Test has χ^2 distribution. The χ^2 table value at 95 percent confidence level for seven degrees of freedom is 14.07. The White Test for each model is well above of this critical value, indicating that the variances of the error term are homocadastic, and our estimated parameters unbiased. The most obvious detection of multicollinearity is meaninglessly high R^2 and low t statistics, which is not the case for our models. Furthermore, existence of multicollinearity does not make the estimated parameters biased. For this reason, any further test such as the variance inflation factor (VIF) to detect multicollinearity is not needed.

Due to lack of data and a dearth of studies, the value of travel time has never been reported for the cities in Turkey. With certain assumptions, it is possible to derive the value of travel time for work trips using mean values, the parameters of the whole area exponential model, and the distance to the subway stations. The Turkish Central Bank mean interest rate during the survey period is used as the value capitalization rate for this computational approximation. It should be noted that the mortgage system loan rate would obviously be a better and more dependable rate for such a computation. However, there was no legislated long-term mortgage finance system in Turkey at the time of the study.

The mean property value in the study area was $37,610. Considering the Turkish Central Bank mean interest rate during the survey period, is 4.123 percent, the annual capitalization amount for the mean housing value would be (37,610 − 0.04123 =) $1,551 and thus, the capitalization period would be (37,610/1,551 =) 24 years and three months for the average house in the area. The mean walking distance to subway station was 535.21 m. An average person working 250 days a year (Dewees, 1976) would walk a total distance of (535.21 − 2 − 250 − 24.25 =) 6,490 km with a daily round-trip during this 24.25 years of capitalization period. An adult walking 4-5 km per hour would walk this total distance in 1622.5 – 1298 hours. Using Equation (3), the marginal contribution of a meter in the exponential model for the whole area at the mean property value comes to (0.00118221 − 37,610 =) $4.446. With this amount, the total value of the mean walking distance over the capitalization period would be (4.446 − 535.21 =) $2,380. Dividing total walking value with these estimated total walking times over capitalization period would produce the value of out-of-vehicle time for subway anywhere between $1.47 and $1.83 per hour as a very rough approximation, and it can be used in the cost-benefit analyses of rail investments until more accurate estimations are available.

6. Conclusion

The immediate conclusion of this paper is that a rail transit investment has altered the land rent curve of the surrounding neighborhoods. In this sense, the theoretical premise "any improvement in transportation infrastructure is capitalized into land values in a short-term urban partial equilibrium" is confirmed one more time in the more compact and densely populated urban environment of a developing country, even after four-years of its operation. This result should convince decision-makers in developing countries that the rail transit investements will provide additional value to the properties beyond their engineering and economical values. Also, the engineers estimating the costs and benefits of such projects should include these additional benefits in their estimates to promote the rail transit investments.

A little reservation to this result could be noted since the effect of the bus transit does not have a significant effect on the property values. Because we could not conduct a "before and after" analysis, we could never know whether bus transit had any impact on the property values, or whether the bus transit had had an impact but the opening of the subway has replaced this impact as re-capitalization. Obviously, clarification of this point requires further research especially after the completion of Izmir Commuter Subway in all neighborhoods with a larger database. Furthermore, the long-term impacts of Izmir Subway should be monitored not only from the perspective of the rent curve but also in terms of changes in land use, density, employment, population, urban revival and economic development in future research.

References

Al-Mosaind, M.A., Dueker, K.J. and Strathman, J.G. (1993), "Light rail transit stations and property values: a hedonic price approach", *Transportation Research Record*, No. 1400, pp. 90-4.

Alonso, W. (1964), *Location and Land Use: Toward a General Theory of Land Rent*, Harvard University Press, Cambridge, MA.

Bajic, V. (1983), "The effects of a new subway line on housing prices in metropolitan toronto", *Urban Studies*, Vol. 20, pp. 147-58.

Bollinger, R.C. and Ihlanfeldt, K.R. (1997), "The impact of rapid rail transit on economic development: the case of Atlanta's MARTA", *Journal of Urban Economics*, Vol. 42, pp. 179-204.

Cambridge Systematics Inc. (1998), "TCRP Report 35: Economic Impact Analysis of Transit Investment: Guidebook for Practitioners", National Academy Press, Washington, DC.

Cervero, R. (1994), "Rail transit and joint development: land impacts in Washington DC and Atlanta", *APA Journal*, pp. 83-93, Winter.

Cervero, R. and Landis, J. (1997), "Twenty years of the bay area rapid transit system: land use and development impacts", *Transportation Research A*, Vol. 31 No. 4, pp. 309-33.

Cervero, R. and Duncan, M. (2002), "Land Value Impacts of Rail Transit Services in Los Angles County", report prepared for National Association of Realtors Urban Land Institute.

Chau, K.W. and Ng, F.F. (1998), "The effects of improvement in public transportation capacity on residential price gradient in Hong Kong", *Journal of Property Valuation & Investment*, Vol. 16 No. 4, pp. 397-410.

Chen, H., Rufolo, A. and Dueker, K.J. (1997), "Measuring the Impact of Light Rail Systems on Single Family Home Values: A Hedonic Approach with GIS Application", Discussion Paper 97-3, *Center for Urban Studies, Portland State University*, Portland.

Dewees, D.N. (1976), "The effect of a subway on residential property values in Toronto", *Journal of Urban Economics*, Vol. 3, pp. 357-69.

Forrest, D., Glen, J. and Ward, R. (1996), "The impact of a light rail system on the structure of house prices", *Journal of Transport Economics and Policy*, Vol. 30 No. 1, pp. 15-29.

Fujita, M. (1989), *Urban Economic Theory: Land Use and City Size*, Cambridge University Press, Cambridge.

Gatzlaff, D.H. and Smith, M.T. (1993), "The impact of the Miami Metrorail on the value of residences near station locations", *Land Economics*, Vol. 69 No. 1, pp. 54-66.

Green, W.H. (1997), *Econometric Analysis*, 3rd ed., Prentice Hall, Upper Saddle River, NJ.

Henderson, V.J. (1988), *Urban Development: Theory, Fact and Illusion*, Oxford University Press, Oxford.

Henneberry, J. (1998), "Transport investment and house prices", *Journal of Property Valuation and Investment*, Vol. 16 No. 2, pp. 144-58.

Laakso, S. (1992), "Public transport investment and residential property values in helsinki", *Scandinavian Housing and Planning Research*, Vol. 9, pp. 217-29.

Knight, R. and Trygg, L. (1977), "Evidence of land use impacts of rapid transit systems", *Transportation*, Vol. 6, pp. 231-47.

Mills, E.S. (1972), *Studies in the Structure of the Urban Economy*, Johns Hopkins University Press, Baltimore, MD.

Muth, R. (1969), *Cities and Housing*, University of Chicago Press, Chicago, IL.

Rosen, S. (1974), "Hedonic prices and implicit markets: product differentiation in pure competition", *Journal of Political Economy*, Vol. 82 No. 1, pp. 34-55.

So, H.M., Tse, R.Y.C. and Ganesan, S. (1997), "Estimating the influence of transport on house prices: evidence from Hong Kong", *Journal of Property Valuation and Investment*, Vol. 15 No. 1, pp. 40-7.

Corresponding author
H. Murat Celik can be contacted at: muratcelik@iyte.edu.tr